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FOREWORD.

PROFESSOR BHOLANATH ROY was a most brilliant and thoughtful student of my Philosophy class when I was on the staff of the Presidency College. It was therefore with considerable interest that I perused his "*Textbook of Deductive Logic,*" and "*Textbook of Inductive Logic*;" and my expectations were amply justified. An experienced teacher of the subject Prof. Roy has presented the essentials of the subject in a manner at once clear and concise, and refrained from a more elaborate treatment of certain topics which at the initial stage are likely to perplex and discourage students. A very welcome feature of the books is the wealth of illustrations, and their value is further enhanced by the insertion in appropriate places of University Questions. The Chapters on Fallacies will be found very helpful. The books are intended to help students to prepare for University examinations and this object they fully achieve. A student who carefully masters the contents of these little volumes should find himself well equipped for the ordeal of examinations.

SENATE HOUSE,
Calcutta, 24th July, 1931 } ADITYANATH MUKHERJEE.

PREFACE TO THE FIRST EDITION.

THE present work is planned on the same lines as its companion volume, *Textbook of Deductive Logic*, published last year and is primarily intended as a textbook for junior students. Portions of the text which are intended for more advanced students have been printed in smaller letterpress, and may be omitted on a first reading when the student is learning the elementary principles and the outlines of the science. The student is also recommended to avail himself of the list of *Exercises* at the end of each Chapter.

The author expresses his large indebtedness to all the standard writers on Logic from whose works he has derived very valuable assistance. He has also received many valuable suggestions from Professors actually engaged in teaching the subject in the dfferent colleges, to all of whom he offers his cordial and grateful thanks.

CALCUTTA,
24th July, 1931. THE AUTHOR

PREFACE TO THE ELEVENTH EDITION.

THE present edition represents a thorough revision of the book. Some portions have been re-written. New paragraphs have been added to some of the sections. The *Exercises* have been re-arranged, and the *Index* has been made exhaustive. The author wishes to express his obligations to Professors who have used the book in the class room for helpful criticisms and valuable suggestions, in particular to Dr. B. L. Atreya, M.A., D.Litt, Professor A. Charles, O.M.I., The Rev. Fr. J. Arul, S.J, Professor Kalyan Chandra Gupta, M.A., P.R.S, and Professor Narendra Nath Das Gupta, M.A. The author also thanks his pupils, Mr, B. M. Chattetree,M.A.. and Mr. H.N. Roy, M.A., for aid in re-arranging the Exercises, preparing the Index and correcting proofs.

CALCUTTA;
20th December, 1946. THE AUTHOR.

Syllabus in Inductive Logic

Calcutta University.

Material Logic. Nature of truth Knowledge and Reality Sources of Knowledge Perception, Inference, Authority, Necessary Truth Generalisation and the General Idea. Science Laws of Nature Uniformity of Nature The grounds and conditions of Inductive Inference Causality Origin of belief in universal causation Energy and conservation. Causes and conditions Plurality of Causes Composition of Causes, and Intermixture of Effects. Discovery and proof Hypotheses: their uses and conditions. Theory, Verification Observation and Experiment, and their uses The Experimental methods and their use, with examples of their application Fallacies of Observation.

Nature, place and use of the Inductive method Perfect and Imperfect, Complete and Incomplete Induction. Inference from Analogy Inference from Simple Enumeration Inductive Probability, Chance and its Elimination Scientific Induction Processes simulating Induction Fallacies in Inductive Reasoning

Classification, Natural and Artificial, and its conditions. Relation of Classification to Division. Definition and its material conditions Description Type Errors in Classification and Definition Terminology and Nomenclature. Nature, place and use of the Deductive Method Relation of Induction and Deduction. Nature, function and value of the Syllogism Inductive and Deductive Sciences The actual Method of Scientific Progress Demonstration The world as a system of law. Explanation and its limits.

Utkal University.

Nature, Problem and Procedure of Induction, Relation of Induction to Deduction.

Postulates of Induction, Uniformity of Nature, and the Law of Causation.

Observation and Experiment Scientific and Unscientific Induction.

Scientific and Popular views of Causation The Conservation of Energy, Plurality of Causes and Intermixture of Effects

The Method of Hypothesis, its place in scientific inquiry. Conditions and verification of Hypothesis.

The Experimental methods, their uses and application.

The Deductive Method and its uses. Chance and Probability as related to the principle of Causality.

Analogy; its nature and value.

Explanations and Laws of Nature.
Classification—
Fallacies in Inductive Reasoning.

Patna University.

Material Logic, Knowledge, Reality and Truth. Different Sources of Knawledge Necessary Truth

The Postulates of Induction Uniformity of Nature and Causation Energy and Conservation. Causes and Conditions. Plurality of Causes and Intermixture of Effects Composition of Causes Material Grounds of Induction. Observation and Experiment and their use The Experimental Methods, their use and application.

Discovery and Proof Hypotheses, their use and conditions Verification of Hypothesis Theory and Fact Deduction in Induction

Science, Laws of Nature The World as unitary system

Generalisation and the General Idea. Abstraction.

Nature, Place and Use of the Inductive Method Perfect and Imperfect, Complete and Incomplete, Scientific and Unscientific Induction Enumerative Induction

Analogy Nature of Analogical Reasoning and its use Analogy and Induction.

Explanation and its Limits Scientific and Popular Explanation

Probability and its grounds Chance and its Elimination

Classification: Natural and Artificial Its conditions Its relation to Definition and Division Classification by Type. Errors in Definition, Division and Classification

Fallacies in Inductive Reasoning Relation of Deduction to Induction Unity of the Inferential Process Inductive and Deductive Sciences

Banaras Hindu University.

1 The problem of Induction The inductive process and its different forms Grounds of Induction Laws of Casuality and Uniformity of nature.

2 Grounds of Induction. Observation and Experiment. Methods of Induction The Deductive Method of Induction.

3 Scientific and Imperfect Inductions Induction by Enumeration and the use of Statistics Induction by Analogy: its nature and value.

4 Hypothesis—Its formation and use Conditions of Legitimate Hypothesis Explanation, Deduction and Induction, and their connection.

5 Fallacies Varieties of Inductive fallacies and nature of each variety.

The Board of Intermediate Education, U. P.

(1) The nature of Induction.
(2) Different kinds of Induction.—Perfect and Imperfect, Scientific and unscientific, simple enumeration and analogy; parity of Reasoning; Colligation of facts.
(3) The formal grounds or presuppositions of Induction Uniformity of Nature and Causation, Concept of causality in Indian Logic.
(4) The material grounds of Induction, Observation and Experiment.
(5) Hypothesis.
(6) The Experimental or Inductive Methods—Anvaya and Vyatireka of Indian Logic.
(7) Inference from Analogy.
(8) The Deductive method of Investigation.
(9) Explanation and establishment of Laws.
(10) Classification.
(11) Terminology and Nomenclature.
(12) Analysis of Inductive arguments and applications of Inductive Methods. Fallacies incidental to Inductive Reasoning

NOTE—(1) Fallacies both Deduction and Induction should be treated under appropriate context, not as a separate topic.
(2) One question on Indian Logic in both the papers, Deductive and Inductive, shall be compulsory.

Board of Intermediate Education, Rajputana (including Ajmer-Merwara, Central India and Gwalior).

The nature and presuppositions of Inductive inference. Causation, its significance and importance in induction. Observation and experiment Classification and Nomenclature Hypothesis. Imperfect inductions. Simple Enumeration and Analogy, Methods of scientific induction. The deductive method of investigation. Analysis of inductive arguments and application of inductive methods Explanation and establishment of laws The relation of induction to deduction. Fallacies.

Punjab University.

I—Definition, scope and Use of Induction. Observation, Testimony, and Experiment Regulative Principles of Observation and Experiment Advantages of Experiment over Observation, Classification and Nomenclature Generalisation.

II—The assumptions of Scientific Induction. The law of Causation Different theories of the nature of cause. Causes and Conditions Plurality of Causes. Intermixture of Effects. Discovery and Proof as the object of Induction.

III—Nature of Hypothesis Conditions of the Validity of an Hypothesis. Empirical Generalisations; and laws of nature. Explanation and its various forms.

IV.—Fallacies of Induction

Madrss University.

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Types of Induction—Enumerative and Scientific.
The Assumptions of Induction.
Stages in the Inductive Process.
Observation and Explanation.
Relative Advantages of experiment over observation.
Simple Enumeration, Statistics and Calculation of chances —their place in induction
DETERMINATION OF CAUSAL RELATIONS —

Cause—Comparison of Scientific with popular view—Plurality of causes—Intermixture of effects. Mill's Experimental methods—General nature—The Method of Agreement The Method of Difference The Joint Method of Agreement and Difference. The Method of Concomitant Variations The Method of Residues Mill's methods—their relation and value—Place of elimination in Induction.

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Relation between Deduction and Induction.

Fallacies of Induction Non—observation, Mal—observation—False cause—Unsound Analogy—Barren hypothesis and Hasty Generalisation.

Bombay University.

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2 Definition.
3 Classification and Division
4 The nature and presupposition of Induction
5 Empirical Laws.
6 Inductive Methods.
7 Observation and Experiment
8 Explanation.
9 Hypothesis.
10 Analogy
11 Fallacies—Inductive.

Ceylon University.

Inductive reasoning in its various forms Observation and experiment Canons of Scientific induction; Combination of induction and deduction; hypothesis and explanation. Fallacies.

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HYPOTHESIS—ITS USES AND CONDITIONS

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Textbook of Inductive Logic

CHAPTER I.

NATURE, PLACE, METHOD AND USE OF INDUCTION.

Sec. 1. Transition to Induction.

In Deduction, we merely aim at Formal Truth and assume the Material Truth of the premises.

It is usual to divide inferences into Deductive and Inductive. In *Deductive Inference,* the premises are assumed to be true, and we merely aim at Formal Truth. Let us attempt to illustrate the full implications of this statement by referring to concrete examples of deductive inferences. To take the following syllogism :—

All men are mortal.
All kings are men.
∴ All kings are mortal.

It is clear that the major and the minor premises constitute our *data, i e.,* materials given to us and *assumed to be true,* without any examination or proof. Our only task is to examine whether the rules of syllogism have been correctly observed, or in other words, whether the argument is formally correct. We find that in this case, the rules have been strictly followed, and the syllogism is in the mood *Barbara.* Hence the argument is *formally* valid. So far as our reasoning is merely deductive, we need not proceed further. It is outside the scope of deductive reasoning to examine whether the given argument is also materially true, *i.e.,* true as a matter of fact.

A deductive argument may be both formally and materially true, or

If, however, we step beyond the limits of Deduction and examine the given argument, we find that this argument is also *materially* true, *i.e* , as a matter of fact, the propositions constituting the argument actually agree with facts *As a matter of fact*—All men *are* mortal, All kings *are* men, and All kings *are* mortal Not only have the formal rules of deductive reasoning been correctly followed but what is more, there is agreement between the thoughts represented

in the constituent propositions and the actual state of things. Thus, in the given example of deductive reasoning, there is *both formal and material truth.*

It should not be thought, however, that Formal and Material Truth always or necessarily go together. It is quite possible that a particular deductive argument may be *formally true but materially false.* To take the following syllogism :—

formally true but materially false.

All men are immortal.
All kings are men.
∴ All kings are immortal.

In this argument, we find that all the rules of syllogism have been observed, and in fact, this argument, formally speaking, is as much valid as the former syllogism, both being in the mood *Barbara. But as a matter of fact, the conclusion is false*, for it is certainly not true that 'All kings are immortal' Thus, the conclusion of the second syllogism is formally true but materially false. Now, on examination we find that the conclusion is materially false, because the major premise, 'All men are immortal', is materially false, whereas the conclusion of the former syllogism is materially true because its premises are materially true.

Thus, the formal truth of a deductive argument depends on the observance of the rules of that form of argument; while **its material truth depends on the material truth of its premise or premises.**

The material truth of a deductive argument depends on the material truth of its premise or premises,

This idea is expressed by **Carveth Read** as follows · "*The relation between the premises of a valid syllogism and its conclusion is the same as the relation between the antecedent and the consequent of a hypothetical proposition.* If A is B, C is D grant that A is B, and it follows that C is D; and similarly, grant the premises of a syllogism, and the conclusion follows. Again, grant that C is not D, and it follows that A is not B; and, similarly, if the conclusion of a

valid syllogism be false, it follows that one, or other, or both of the premises must be false". [4th edn., p 159.]

But how to prove the material truth of the premises?

Now Deduction no doubt aims at formal truth merely, and not at material truth. But Logic as a whole aims both at formal truth and at material truth. Hence the question arises—**How to establish the material truth of the premises?**

particularly of Universal premises?

If the premise in question be a particular proposition, its truth can easily be established by an appeal to experience. For example, ordinary observation shows that *some* men are honest, that *some* animals are quadrupeds, that *some* men are mortal, that *some* material bodies attract one another etc. But in a syllogism both premises cannot be particular—one premise at least must be universal. **How then are we to establish the material truth of a universal premise?**

Not Universal Verbal propositions but Universal Real propositions

If the universal proposition be an Analytical or Verbal proposition, there is no difficulty in establishing it. An Analytical or Verbal proposition is one in which the predicate does not say anything new but merely states the connotation (or a part of the connotation) of the subject as distinguished from a Synthetical or Real proposition, in which the predicate asserts an additional fact, which an analysis of the connotation of the term does not reveal. Thus, the proposition 'All men are rational' is an analytical proposition, because, the predicate is a part of the connotation of the subject. It is clear that the universal proposition 'All men are rational' can easily be established, by an analysis of the meaning of the term 'man' because we know that the very meaning of the term 'man' is that he possesses the attributes

'rationality' and 'animality'. To reach a universal proposition of this nature, it is not at all necessary to appeal to experience. But **how are we to establish universal real propositions?** How are we to reach universal propositions, the predicates of which are not found to belong to the subjects merely by an analysis of their connotation?

If the Universal Real propositions are neither (i) Axioms,

Universal Real propositions may have *three sources*: (*i*) *Axioms*, (*ii*) *Deductions* from more general propositions; and (*iii*) *Inductions.*

(*i*) AXIOMS. Axioms are universal real self-evident propositions. They are *self-evident,* i.e., they do not require any proof; *e.g.,* the Laws of Identity, Contradiction, Excluded Middle etc. These Axioms are however very few in number, and the vast majority of general propositions are not axioms. [P. 259.]

(ii) nor Deductions.

(*ii*) DEDUCTIONS FROM MORE GENERAL PROPOSITIONS. Some Universal Real propositions may be deductions from more general propositions. It is possible to think that the general proposition, which forms the premise of a particular syllogism, is the conclusion of another syllogism, that the premises of the latter, again, are proved by yet another syllogism, and so on. Thus, 'All men are mortal,' because, 'All animals are mortal' and 'All men are animals'; again 'All animals are mortal' because, 'All living beings are mortal' and 'All animals are living beings'; and so on. It is clear that this cannot carry us very far. This is merely putting off the difficulty—a *regressus ad infinitum* (regression or going backwards to infinity). This is no solution of the problem. The process backwards must have an end. In the end, we reach universal propositions which cannot be formally established. It is in this sense that it has been said that *the ultimate major premise of a chain of deductive reasoning is the result of Induction,* and not of Deduction.

(iii) they can only be proved by Induction.

(*iii*) Inductions. How then are we to establish Universal Real propositions which are neither axioms nor deductions? The answer is—by Induction. It is Induction which establishes the vast

majority of general propositions. While Deduction assumes the material truth of its universal premise, Induction proves it. Deduction takes for granted that its universal premises are true, without challenge, without proof; while Induction seeks to prove that the general propositions are materially true—that they agree with the facts of experience. Hence it has been said that *Induction supplies the universal premises of Deduction.*

Summing up:

To sum up: Deduction aims merely at Formal Truth and assumes the truth of universal premises. But Logic deals with both Formal and Material Truth. How then are we to prove the material truth of a universal premise?

If the Universal premise be merely an analytical (or verbal) proposition, there is no difficulty. But how are we to prove Universal *Real* propositions?

Universal real propositions may have *three* sources:—

(*a*) *Axioms.* Both Deduction and Induction assume their truth without proof, but they are only a few in number. What about *other* Universal Real propositions?

(*b*) *Deductions.* Some Universal Real propositions may be deductions from more general principles. But this is merely putting off the difficulty. The ultimate universal premise is not a deduction. How then is it established?

(*c*) *Induction.* Induction establishes Universal Real propositions, and supplies the universal premises of Deduction.

THE PROBLEM OF INDUCTION.

The premises of Induction come from experience

Induction seeks to establish the material truth of universal real propositions. This is possible only if the premises from which the universal propositions are drawn are materially true, *i.e.*, derived from facts of experience.

which however furnishes particular facts

Experience, however, primarily furnishes us with particular facts, and not with universal propositions. Experience informs us that *some* men whom we knew are dead, not that *all* men are mortal. Similarly, one

learns from experience that particular pieces of iron have a coating of rust in the rainy season by coming in contact with moisture, but experience, as such, cannot teach that water rusts iron *in all cases*. Newton saw an apple fall to the ground, possibly he saw other apples fall, some other fruits fall, some leaves fall, some other material bodies fall, but he could not possibly have seen *all* material bodies, not even *all* apples, fall to the ground.

From these experiences of particular facts, the average man, not to speak of the scientist, is constantly seeking to establish general propositions. The general propositions, when established, not only embrace the cases which have come into experience but all similar cases, experienced or not. Thus we freely conclude—all men are mortal, in all cases water rusts iron, all material bodies attract one another, and so on. In all these cases, the number of instances observed is infinitely small compared with the full number of which the statement is made. *It may even happen that the careful examination of a single case is sufficient to justify a universal conclusion.*

from which general propositions are proved.

The establishment of a general truth on the basis of particular experiences is called *generalisation*. It is the function of Induction to enquire into and determine the conditions under which generalisations are valid. **Joyce** defines Induction as *"the legitimate derivation of universal laws from individual cases."* Similarly, **Fowler** defines Induction as *"the legitimate inference of the general from the particular or... ....of the more general from the less general"*. Under what conditions such inference of universal laws becomes legitimate—how we are

Hence Induction involves Generalisation.

Under what conditions does Generalisation

become valid?

able to derive from experience general real propositions—how we are justified in inferring the general from the particular, or the more general from the less general—is the **problem of Induction. Mill** formulates the problem in the following eloquent passage: "Why is a single instance, in some cases, sufficient for a complete induction, while in others myriads of concurring instances, without a single exception known or presumed, go such a very little way towards establishing an universal proposition? Whoever can answer this question knows more of the philosophy of Logic than the wisest of the ancients, and has solved the problem of Induction."

Generalisation becomes valid when we rely on Laws of Uniformity and Causation.

The **solution** to this problem lies in the fact that in passing from the particular to the general, Induction* relies on two fundamental principles *viz*, the Law of the Uniformity of Nature and the Law of Causation. The Law of Causation states that every event has a cause. The Law of the Uniformity of Nature says that the same cause produces the same effect under similar conditions. In Induction we observe particular cases of death, and finding that there is something in 'humanity' which causes 'mortality,' extend the result to other similar cases on the assumption that the same cause will produce the same effect, under similar circumstances, in all places, and at all times.

In other words we discover a

The same idea may be expressed in a different way. A closer examination of the particulars reveals that they

*We may mention here that this is Induction in its ideal form, called *Scientific Induction.* Besides this, there are certain weaker forms of Induction which will be dealt with in subsequent sections. [P. 18].

possess certain essential characteristics, and certain other characteristics which are variable and accidental. The accidental characteristics are eliminated or discarded, while attention is focussed on the essential characteristics constituting the inner essence of the particulars. The particulars are not *mere* particulars, they are in essence manifestations of the universal. The problem of Induction is solved when this universal element is discovered and proved. **universal** element in the particulars

Sec. 2. Scientific Induction*—Its marks or characteristics.

Scientific Induction is the establishment of a general real proposition, based on observation of particular instances, in reliance on the principle of the Uniformity of Nature and the law of Causation. Let us analyse fully the implications of this definition, and determine the *characteristics* or *marks* of Scientific Induction, as distinguished from other forms of thinking and reasoning :— Definition

1. *Firstly*, **Induction establishes general real propositions.** 1 Induction establishes

(*a*) Induction establishes a **proposition.** A Proposition explicitly states a relation between two terms. The conclusion in Induction is a proposition, because, in it, we seek to prove a connection (a) a proposition

*Two points should be noted:

(*a*) In this section we deal with the ideal form of Induction, known as *Scientific Induction.* Other forms will be mentioned in Sec. 3 of this chapter. [P. 14].

(*b*) The word 'Induction' is sometimes used to mean the *process* of reasoning from particulars to a general proposition, and sometimes, to mean the *product* of such reasoning, *viz.*, the general proposition itself, which is the conclusion of the process.

between two terms. Thus we prove that there is a connection between 'man' and 'mortality', and establish the Induction 'Man is mortal'.

This characteristic distinguishes Induction from *Conception* and *Definition* which deal with *Notions*, and not with propositions. (See p. 14.)

(*b*) The propositions established by Induction are **general propositions.** A *general proposition* is one in which a predicate is affirmed or denied of an indefinite number of individuals, *e.g.*, All men are mortal; here the predicate 'mortal' is affirmed of *all* men who constitute an indefinite number of individuals.

(b) which is a general proposition and

A GENERAL PROPOSITION should, firstly, be distinguished from a *particular proposition.* In a particular proposition, the predicate is affirmed or denied of some individuals only, *e.g.*, Some men are mortal, while, in a general proposition, the predicate is affirmed or denied of an indefinite number of individuals Secondly, *really* general propositions should also be distinguished from *those which are only general in form.* For example, the proposition 'All known continents have large rivers' is only general in form, not in substance, because the predicate 'possessing large rivers' is not affirmed of an indefinite number of continents but only of the known continents. Supposing a new continent were raised from the bottom of the ocean, we cannot say that the attribute will be possessed by it also. But when we establish a really general proposition 'All men are mortal' (as in Induction), the attribute 'mortality' is possessed not only by all known men, but also by all men who lived in the past, by all those who are living at the present moment, in the different parts of the globe, and will be possessed by all men who are yet to be born. This point will be made more clear, when we consider that in Induction there must be an "inductive leap" from the known to the unknown. [P. 12]

It may, however, be pointed out that the propositions established by Induction may have varying degrees of generality, *i.e.*, some inductions may be more general, covering a

larger number of cases than others. For example, the proposition 'All men are mortal' is less general than the proposition 'All animals are mortal' but the former proposition is *no less inductive* than the latter. The more general propositions may possess more value as knowledge, but are not more inductive.

(c) The general propositions, which Induction establishes, are not Verbal but **Real propositions.** *A Verbal proposition* merely states the connotation or a part of the connotation of a term; for example, All men are rational. A *Real proposition*, on the other hand, does not merely analyse the connotation of a term but adds something new to our knowledge, for example, the proposition "All men are mortal" is a *real proposition*, because, the predicate 'mortal' connotes an attribute which is not a part of the connotation of the term 'man'. (c) a real proposition.

2. *Secondly*, **Induction is based on Observation of facts.** 2 Induction is based on Observation.

The general propositions established by Induction are based on observation of particular instances. Thus they are distinguished, on the one hand, from Axioms, and, on the other hand, from Deductions. *Axioms* are self-evident general propositions, which cannot be proved but must be assumed to be true, while general propositions in Induction are proved. Again, in *Deductions*, general propositions are derived from propositions more general, while the general propositions in Induction are derived from observation of particular instances. For example, the general proposition "All men are mortal" is based on an observation of particular cases of death of persons we have come across.

This characteristic shows that *Induction aims at Material Truth*—that the general propositions

established by Induction must conform to the actual state of things.

3 In Induction, there is a leap from the known to the unknown.

3. *Thirdly*, **in Induction, there is an "Inductive leap or hazard."**

Mill describes Induction as a process "from the known to the unknown". **Bain,** following Mill, calls this the "Inductive leap" or "hazard of Induction". Thus *the Inductive leap consists in passing from the observed cases to the unobserved cases* ..... "to the *future* which has not yet come within observation, to the *past* before observation began, to the *remote* where there has been no access to observe". It is clear that this passage from the known to the unknown, from the observed to the unobserved, involves some hazard or risk. According to Mill and Bain, this Inductive leap or hazard constitutes the very essence of Induction; if this characteristic be wanting, the process cannot be called Induction at all. This characteristic distinguishes Induction from the so-called *Perfect Induction* of the *Scholastics*. (See Sec. 4A, p. 18.)

But the so-called unknown is really partially known because it resembles the latter.

The characteristic follows from the circumstance that Induction establishes a general proposition which embraces a large and indefinite number of unobserved facts. **Mellone** points out that while it is quite correct to say that in Induction, we pass from the particular to the general, it is misleading to describe Induction as an inference "of the unknown from the known, of the future from the past". The new or "unknown" or "future" cases are not strictly *unknown*, because the inference would be correct only when we *know* that these unobserved cases resemble the observed cases in important respects. Hence Mellone says: "It would be less incorrect to speak of passing 'from the *comparatively known* to the *comparatively unknown*'.........but this is much better expressed by saying that what we reach is a general proposition."

4. *Lastly*, **Scientific Induction is based on two presuppositions, viz., the Law of Causation and the principle of the Uniformity of Nature.** These two fundamental principles are called the *formal grounds* of Scientific Induction, because Scientific Induction must take them for granted in order that a general proposition may be established on an observation of particular instances. They are also called the *postulates* or *assumptions* of Induction. 4. Induction presupposes

The Law of Causation states— *every event must have a cause.* Scientific Induction is based on the Law of Causation. For example, a causal connection is proved between 'humanity' and 'mortality', and the general proposition "All men are mortal' is established on the strength of this causal connection. This characteristic of Scientific Induction distinguishes it from a weaker form of Induction called *Unscientific Induction* or *Induction per Simple Enumeration* in which a knowledge of the causal connection is wanting. (See p. 29) the Law of Causation

Induction is also based on **the principle of the Uniformity of Nature.** This principle states that *under similar conditions, the same cause produces the same effect.* Now, when we find that there is a causal connection between 'humanity' and 'mortality', we further assume that this causal relation will be true in all cases, under similar circumstances. and the Law of Uniformity of Nature.

Thus Scientific Induction establishes general real propositions, on the evidence of particular instances, in reliance on the principles of Causation and the Uniformity of Nature.

Conception is the process of forming concepts.

Note. Induction and Conception or Definition.

CONCEPTION is the process of forming concepts. In forming a concept or a general notion, we, first of all, compare a number of individuals with one another, find out the essential qualities in which these individuals agree, separate the common and essential attributes from the variable and accidental ones, generalise the common and essential attributes, and lastly, give a name to the group of generalised attributes. (*Textbook of Deductive Logic*, Ch. I, Sec. 5). Thus in forming the concept 'man' we compare several human beings, find that they possess the common and essential attributes 'animality' and 'rationality', think of these attributes separately, recognise that they are also possessed by other human beings, and finally, the generalised group of common and essential attributes is given the name 'man'. Thus, Conception or the process of forming concepts involves Comparison, Abstraction, Generalisation and Naming. A concept expressed in language is called a Term.

Definition states the meaning of concept.

DEFINITION means the statement of the connotation of a term. A Definition, thus, is nothing but the unfolding of a concept. It merely analyses what is contained in a concept. In simple language, a definition states the meaning of a concept.

Considered as a process, Induction is of the same nature as Conception

CONSIDERED AS A PROCESS, INDUCTION IS OF THE SAME NATURE AS CONCEPTION. Induction, like Conception, involves the processes of Comparison, Abstraction and Generalisation. Through Induction, as well as through Conception, the human mind grasps the essential qualities of a thing. The difference between Induction and Conception is that in the case of Induction, we establish a proposition, while in the case of Conception, we merely establish a concept or Notion.

In Definition, the conjunction is assumed; in Induction it is proved.

As to the distinction between DEFINITION AND INDUCTION, we cannot do better than quote the words of **Bain**: "There is no small delicacy in placing the boundary between definitions and proper inductive generalisations. We have to ask, whether or not, the stress is laid on the circumstance of *conjunction*, whether it is made a question—are the properties conjoined or not? In Definition, the conjunction is tacitly assumed; in Induction, it is laid open to question; it has to be *proved* or *disproved*."

Sec. 3. Different kinds of Induction.

Inductions are divided into

In the preceding section, we examined the characteristics of Induction in its ideal form, known as Scientific Induction.

The word 'Induction', however, is highly ambiguous and has been used in various senses.

Following **Mill,* generally**, we may first of all distinguish between (1) Inductions improperly so-called and (2) Inductions proper.

(1) Inductions improperly so-called and

As for *Inductions improperly so-called, i.e.*, those processes which have been called Induction but which should not be so called, Mill mentions *three types, viz.*, (*a*) Perfect Induction, (*b*) Induction by Parity of Reasoning and (*c* Colligation of Facts.

(2) Inductions proper

As for *Inductions proper*, they may be sub-divided into (*a*) Scientific Induction; (*b*) Unscientific Induction; and (*c*) Argument from Analogy.

The following **Table** will illustrate the classification :

Induction
- Inductions improperly so-called
  - Perfect Induction
  - Parity of Reasoning
  - Colligation
- Inductions proper
  - Scientific Induction
  - Unscientific Induction
  - Analogy

*According to Mill, "Induction is the process by which we conclude that what is true of certain individuals of a class is true of the whole class, or what is true at certain times will be true in similar circumstances at all times". Mill next proceeds to distinguish Induction from certain operations to which the name 'Induction' has been improperly applied *viz.*, Perfect Induction, Parity of Reasoning and Colligation. These are not Inductions at all ; they are Inductions improperly so-called. In the next chapter Mill refers to Induction by Simple Enumeration as "the kind of *Induction* which is natural to the mind when unaccustomed to scientific methods". Thus it is Induction, though *Unscientific* Induction. Again, in Ch. XX Mill defines 'Analogy' as "some kind of argument supposed to be of an *inductive* nature but not amounting to a complete induction". Thus Mill applies the name 'Induction' to 'Analogy' also.

Note 1. Imperfect Induction.

In our classification of the different kinds of Induction, we have taken particular care to avoid the expression "Imperfect Induction" for the very good reason that though a very common expression it is highly ambiguous, and has been used in conflicting senses.

By 'Imperfect Induction', the Scholastics understood what modern logicians call Induction by Simple Enumeration.

1. The expression "IMPERFECT INDUCTION" was used by *the Scholastic Logicians* of the Middle Ages as the antithesis of what they called "Perfect Induction". They defined "*Perfect Induction*" as the establishment of a universal proposition on an examination of *all* the particulars coming within its sweep, and "*Imperfect Induction*" as the establishment of a universal proposition on an examination of *some* of the particulars only. If we fully appreciate the implications of this definition, Imperfect Induction will not only include Unscientific Induction (or Induction by Simple Enumeration) but also Scientific Induction. The Scholastic Logicians, however, had only a vague and inadequate idea of Scientific Induction, and they did not include Scientific Induction under their definition of Imperfect Induction. The modern conception of Scientific Induction was only dimly recognised by the Scholastics, and they did not call it Induction at all, but they called it "*Proof from experience.*"

Some modern logicians use the term to mean both Simple Enumeration and Scientific Induction

2. Some modern Logicians (e.g., **Carveth Read**) have adopted the definition of Imperfect Induction given by the Scholastics, and putting upon it the modern construction of which it is capable, (though the Scholastics did not understand it in that extended sense) have sub-divided Imperfect Inductions into *Imperfect Immethodical Induction* (same as Unscientific Induction or Induction by Simple Enumeration) and *Imperfect Methodical Induction* (same as Scientific Induction). Thus :

- Induction
  - Perfect
  - Imperfect
    - Immethodical (or Unscientific Induction)
    - Methodical (or Scientific Induction)

3. More frequently, however, modern Logicians use the expression "Imperfect Induction" as the antithesis of Scientific Induction, and in this sense, it includes Induction by Simple Enumeration and Argument from Analogy. These forms of reasoning are called *imperfect* because they are not based on the knowledge of a causal connection, and thus fall short of Scientific Induction.

Others use the term as the opposite of Scientific Induction

Induction proper

Scientific Induction

Imperfect Induction

Unscientific Induction

Analogy

Note 2. Complete and Incomplete Induction

1. The expression 'COMPLETE INDUCTION' has been employed by some writers as a synonym for Scientific Induction. As the antithesis of Complete Induction, used in this sense, INCOMPLETE INDUCTION will include both Unscientific Induction and Analogy. These are *incomplete* in the sense that no causal connection has been discovered or proved.

Complete Induction = Scientific Induction

2. Certain Logicians, e.g., **Bain**, use the expression "Complete Induction" to include not only Scientific Induction but also Unscientific Induction. As Bain says: "A Complete Induction................ is a generalisation that shall express what is conjoined everywhere and at all times." Following this use of the term, we may subdivide Complete Induction into

Complete Induction = Scientific and Unscientific Induction

(*i*) *Complete Methodical Induction*, which is the same as Scientific Induction; and

(*ii*) *Complete Immethodical Induction*, which is identical with Unscientific Induction.

As the antithesis of Complete Induction, in this wider sense, "Incomplete Induction" would perhaps only denote Analogy, which is an inference from the particular to the

particular, and thus *incomplete* in the sense that there is no generalisation—no arriving at a general proposition.

In view of this ambiguity, it is safer to discard the use of these expressions altogether.

Sec. 4. Inductions improperly so-called or Processes simulating Induction.

Inductions improperly so-called are those processes of reasoning which differ from inductions proper in essential characteristics, though, superficially they have the same appearance Hence, these processes are also called "**Processes simulating Induction.**" They have the semblance of Induction, but they are substantially different in character. **Mill** recognises *three* types of these processes, *viz.*, *Perfect Induction*, *Induction by Parity of Reasoning* and *Colligation of Facts* Let us consider these processes at length

Three types

A. PERFECT INDUCTION OR INDUCTION BY COMPLETE ENUMERATION.

The SCHOLASTIC LOGICIANS of the Middle Ages divided Induction into Perfect and Imperfect According to them, **Perfect Induction is the establishment of a universal proposition, on an examination of all the particular instances covered by it;** while, *Imperfect Induction* is the establishment of a universal proposition, on an examination of *some* of the particulars only

In Perfect Induction, all the particulars are separately observed.

In Perfect Induction, we separately examine each and every particular instance coming within the scope of a universal proposition, and finding that a certain statement is true in respect of every one of them, we state the results of our separate

observations in the form of a universal proposition. For example, if on observing that each and every one of the *known* planets shines by the sun's light, we state the proposition 'All the *known* planets shine by the sun's light', we have an illustration of Perfect Induction. If, on the other hand, on observing that all the *known* planets shine by the sun's light, we establish the universal proposition 'All planets (*known and unknown*) shine by the sun's light', we have an example of Imperfect Induction.

Examples.

Other examples of Perfect Induction :—

(1) Peter, Paul, John and every other Apostle were Jews Therefore, all the Apostles were Jews.

(2) January, February, March ....December each contains less than 32 days. Therefore, all months of the English year contain less than 32 days each.

(3) Every individual student of a particular class is found to be an Indian, or to have prepared his lessons. Therefore, all the students of that class are Indians, or all the students of that class have prepared their lessons.

(4) Europe has large rivers; so Asia, so Africa, so America Therefore, all known continents have large rivers

(5) A man examines all the books in a bookcase, and seeing that they are works of fiction says "All the books in the bookcase are works of fiction."

Perfect Induction is possible only when there is a *limited totality* i.e., when the whole consists of a limited number of parts. But when the whole consists of an unlimited number of parts, there cannot be a Perfect Induction. Thus we cannot by Perfect Induction establish the proposition 'All men are mortal', because the number of human beings is unlimited, and all of them cannot be separately examined

Perfect Induction is possible only when there is a limited number of particulars

Perfect Induction of the Scholastic Logicians has been named **Induction by Complete Enumeration** by modern Logicians, because, the

It is called 'Complete Enumeration'.

universal proposition is established on an enumeration or counting of *all* the particulars within its sweep. Induction by Complete Enumeration is contrasted with *Induction by Simple Enumeration* or Unscientific Induction in which the universal proposition is established on a counting of *some* of the particulars only.

Is Perfect Induction, Induction at all ?

Mill and **Bain** are of opinion that the so-called Perfect Induction of the Scholastic Logicians, far from being perfect, is not Induction at all, for the following reasons:

In Perfect Induction, there is no inductive leap and hence there is no real inference.

Firstly, according to Mill and Bain, the essence of Induction lies in an "inductive leap" from the known to the unknown. In Perfect Induction, however, this characteristic quality of Induction proper is wanting. There is "no real inference, no march of information, no addition to our knowledge" (Bain). It is "a mere shorthand registration of facts known" (Mill). Nothing more is stated in the conclusion than what is given in the premises.

The proposition arrived at in Perfect Induction is general, only in appearance.

Secondly, the proposition arrived at in Perfect Induction is *a general proposition, only in appearance;* while, in reality, it is nothing but "a number of singular propositions written in an abridged character" (Mill). For example: the Perfect Induction "All the known continents possess large rivers" is nothing but an abridged form of expressing four singular propositions, *viz.,* 'Asia possesses large rivers,' 'Europe possesses large rivers,' Africa possesses large rivers' and 'America possesses large rivers'.

Dr. P. K. Ray holds the view, as opposed to the views of Mill and Bain, that Perfect Induction cannot be denied the character of Induction. According to him, in Perfect Induction as well as in other forms of Induction, "there is reliance on the Uniformity of Nature" When, on an examination of all the known planets, we arrive at the Perfect Induction "All known planets move round the sun' we rely on the Uniformity of Nature, because we believe that all the known planets not only moved round the sun when we observed them, but they would continue to move round the sun in future. Hence Perfect Induction should also be recognised as a true form of Induction.

Dr. Ray. Perfect induction is Induction, because it relies on the Uniformity of Nature.

Value of Perfect Induction.

Perfect Induction was called *perfect,* because it was supposed that there is perfect or absolute certainty about the truth of the conclusion; while Imperfect Induction was called *imperfect,* because the universal proposition, comprising, as it does, instances which have not been examined, cannot but be more or less uncertain. Among modern Logicians, **Jevons** adopts this viewpoint, and explains it in the following passage. "It must be carefully remembered that no Imperfect Induction can give a certain conclusion. It may be highly probable or nearly certain that the cases unexamined will resemble those which have been examined but it can never be certain..... ......Perfect Induction, on the other hand, gives a necessary or certain conclusion"

It is said that Perfect Induction gives certain conclusions because all are examined.

Fowler combats this view of Jevons, and maintains that "many of our inductive inferences have all the certainty of which human knowledge is capable." When a causal connection is established, the conclusions of Induction attain the highest degree of certainty. Only the guarantee of certainty in Perfect Induction is complete enumeration, while that in Scientific Induction is the proof of a causal connection.

Fowler points out that Scientific Inductions also give certain conclusions.

Some Logicians go further and maintain that the certainty of the conclusion of Perfect Induction falls short of the certainty proceeding from a proof of a causal connection As **Grumley** puts it: "Even when counting is complete it does not give us scientific knowledge. A characteristic that is found to belong to every individual of a class may be no more than an inseparable accident." Hence even perfect enumeration cannot acquaint us with the essential nature of the object, which can only be known through proof of a causal connection.

Can enumeration furnish scientific certainty?

Importance of Perfect Induction.

As for the **importance of Perfect Induction** apart from the question of its logical character, Logicians do not dispute the estimate of **Jevons** who says "If Perfect Induction were no more than a process of abbreviation, it is yet of great importance and requires to be continually used in science and common life Without it, we should never make a comprehensive statement. but should be obliged to enumerate every particular . . ..The power of expressing a great number of particular facts in a very brief space is essential to the progress of science ....Perfect Induction is absolutely necessary to enable us to deal with a great number of particular facts in a very brief space." (*Elementary Lessons*, p. 214). Even Mill recognises that the operation of writing a number of propositions in an abridged character, which Perfect Induction involves may be very useful, and it plays an important part in the preparation of the materials for the investigation of truth.

B. INDUCTION BY PARITY OF REASONING.

Illustrated in geometrical proofs

Induction by Parity of Reasoning is another process of inference which has been called Induction, but in reality, it is substantially different from Induction proper.

Definition.

Induction by Parity of Reasoning is a process of inference in which we establish a general proposition on the ground that the same reasoning which establishes a particular case will establish every other similar case coming under the general proposition.

This process of inference is called *Parity of Reasoning* because *parity* (or *similarity*) is the ground of passing from a particular case to a general proposition. This is illustrated in **geometrical proofs.**

For example, we draw ABC, the diagram of a triangle, on a piece of paper or on the blackboard and prove that its three angles are equal to two right angles. Having proved this with the help of this diagram, we establish the general proposition—All triangles have their three angles as equal to two right angles—because *the same reasoning which applies to this diagram will apply to every other diagram of a triangle which we may draw*.

Parity of Reasoning and Perfect Induction.

In Induction by Parity of Reasoning the conclusion is really a general proposition while in Perfect Induction it is not so.

In Induction by Parity of Reasoning, the conclusion is a general proposition, as in Induction proper. In Perfect Induction, on the other hand, the conclusion is a general proposition only in appearance, while in reality, it is only a number of singular propositions written in an abridged form. The proposition "All triangles have their three angles as equal to two right angles" is really a general proposition, while the proposition "All known continents possess large rivers" is a summary of four singular propositions, *viz.*, Asia possesses large rivers, Europe possesses large rivers, Africa possesses large rivers and America possesses large rivers.

Parity of Reasoning and Induction proper.

(1) In Induction by Parity of Reasoning, there is *no observation* of facts and as such it should not be called Induction

Mill points out that Induction by Parity of Reasoning is "an induction improperly so-called" because one of the essential characteristics of Induction proper, *viz.*, *reliance on observation of facts*, is wanting in it. In Induction proper, the general proposition is established on an observation of particular instances. For example, the general proposition "All men are mortal" is based on an observation of several particular cases of death. *In the so-called Induction by Parity of Reasoning*, on the other hand, *there is no observation at all*. The general proposition "All triangles have their three angles as equal to two right

angles" is not based on the observation that several triangles, ABC, DEF, XYZ, etc., have been found to possess the attribute. What we do is that we take a particular diagram. This diagram stands for all triangles at once. Hence when something is proved of the diagram, it is at once proved of all the things for which the diagram stands. We do not observe the peculiar concrete characteristics of the particular diagram e g., the length of its sides, the size of its angles etc The diagram is used for the purpose of explanation or illustration. As **Carveth Read** says · "Diagrams are not used as facts of observation, but merely to fix our attention in following the general argument". Hence Parity of Reasoning is not Induction proper.

Geometrical figures are abstract conceptions. Hence in Parity of Reasoning there is no observation of facts.

In order to appreciate this point more fully, it is necessary to understand precisely the nature of geometrical figures. A *triangle* for example is defined as a plane figure bounded by three straight lines, and a *line* is defined as possessing length but no breadth. Now in experience we never come across anything possessing length only but no breadth. Hence a geometrical line is not a concrete reality but an abstract conception, and a triangle which is made up of lines must necessarily be also an abstract conception. In fact, *all geometrical figures are abstract concepts, and not real things*. Hence in geometry, when we draw a diagram of a particular kind of figure, the diagram stands for the whole kind The diagram of a triangle is not *a* triangle but is the symbol of all triangles. It stands for all triangles at once. Hence in Geometry, we do not say—ABC *is* a triangle—but "Let ABC be a triangle," or "Suppose ABC to be a triangle." In referring to individual human beings, on the contrary we never say—"*Suppose* Socrates is a man." Socrates was a concrete human being but the diagram ABC is not a concrete triangle Hence if we prove something of Socrates, it does not necessarily follow that the same thing would be true of all men Socrates is a philosopher, but it does not follow that all men are

philosophers. It is different in the case of a diagram or symbol. If something be found to be true of a diagram, it is necessarily true of all the things which the diagram stands for Hence if it be true of ABC, the diagram of a triangle, that the sum of its three angles is equal to two right angles, it necessarily follows that the said characteristic is true of all triangles.

(ii) Geometrical reasonings are *deductive* in character.

It should be pointed out that geometrical reasonings are in no sense inductive, but are purely *deductive in character*. In Geometry, we start with certain axioms, postulates and definitions, and we proceed deductively to draw conclusions from them. For example, we define a triangle as "a plane figure bounded by three straight lines." From this definition, the conclusion "All triangles have their three angles as equal to two right angles" follows deductively. The attribute "equality of three angles to two right angles" is a *property* of 'triangle' because it follows from the connotation of the latter. Hence the proof is a deduction from the definition of "triangle".

Thus the so-called *Induction by Parity of Reasoning is not Induction at all but is a purely deductive process.*

Note. Induction in Mathematics.

Induction in Mathematics is illustrated in (i) Geometrical reasoning; (ii) Algebraical reasoning; (iii) a process technically known as Mathematical Induction.

Geometrical Induction.

1. **Geometrical Reasoning:** The nature of a geometrical reasoning has been fully discussed above, and it has been shown that far from being inductive in character, it is *the very type of deductive reasoning.*

Algebraical Induction.

2 **Algebraical Reasoning:** Having proved in a particular case that

$$(a+b)\ (a-b)=a^2-b^2$$

we know that the conclusion is of universal validity, whatever the quantities these letters may represent.

This process of reasoning, like geometrical reasoning, is not Induction at all because the proof follows from the definitions and rules of algebra deductively, and not from observations of particular cases.

Mathematical Induction.

3. **Mathematical Induction:** The expression "Mathematical Induction" may be employed to include the above two processes as well as the one which is about to be explained. It is however usual to restrict the use of the expression to the following case

"Mathematical Induction" is the technical name of a process of generalisation arrived at by calculating a number of terms of an algebraical or arithmetical series. The following example will illustrate this: If we take the first *two* consecutive odd numbers 1 and 3, and add them together, the sum is 4, *i.e.*, exactly *twice two*; if we take *three* such numbers 1, 3, 5, the sum is 9, *i.e.*, exactly *three times three*; and so on, thus

$$1+3=2^2$$
$$1+3+5=3^2$$
$$1+3+5+7=4^2$$

etc.

From this we lay down the general law, called the Law of the Series, 1, 3, 5, 7................up to n terms $= n^2$; in other words, we state the law—the sum of any number of odd terms beginning with 1 is equal to the square of that number.

Difference between Mathematical Induction and Physical Induction.

Mill points out that this is not Induction proper because the mathematician arrives at the law only "when it is apparent from *a priori* considerations that the mode of formation of the subsequent terms must be similar to the formation of terms which have been already calculated". **Mellone** points out that a general law can be proved from individual cases on two conditions *viz*,, (1) we must be sure that we have really grasped something essential in the particular cases, and are not arguing from accidental qualities, and (ii) we must be sure that any new case exactly resembles the old in those characteristics on which the proof depended Now the difference between Mathematical Induction and Physical Induction (*i.e*, Induction as applied in physical sciences) is that while in mathematics, both conditions are absolutely secured, (for the

mathematician makes his own definitions of what is essential, and argues from them) in Nature, the essential conditions have to be discovered and proved.

C. COLLIGATION OF FACTS.

According to **Mill**, Colligation of Facts is another process which is improperly identified with Induction.

Colligation of Facts means union of facts by means of a suitable notion.

The term '*Colligation of Facts*' was originally used by **Whewell.** To colligate literally means to *bind together;* and the expression **'Colligation of Facts' means the binding together or mental union of a number of observed facts by means of a suitable notion.** Mill defines Colligation thus:—"Colligation is that mental operation which enables us to bring a number of actually observed phenomena under a description; or which enables us to sum up a number of details in a single proposition"

EXAMPLES:—(*i*) A navigator sailing in the midst of the ocean discovers land, he cannot at first determine whether it is a continent or an island; but he coasts along it, and after a few days he finds he has completely sailed round it, he then declares it to be an island. This is Colligation of Facts because, the navigator brings together, under the conception or notion of an island, the set of facts observed by him.

(*ii*) *Kepler's discovery of the orbit of Mars* furnishes another example of Colligation of Facts. The object of Kepler was to determine the orbit or the path described by the planet Mars in revolving round the Sun He could not possibly observe the progress of the planet continuously like the navigator in the former example. So he observed a great number of successive positions occupied by the planet at different periods of the year, and expressed the whole series of observed places of Mars by, what Whewell calls, the 'general conception of an ellipse'.

Colligation and Induction.

Colligation is practically the same as Conception or the process of forming **general notions.**

Induction, on the other hand, establishes propositions. (See p. 14).—Thus while Colligation is concerned with notions, Induction is concerned with propositions, and it would be improper to regard Colligation as Induction.

Whewell identifies Colligation with Induction. Mill's criticism.

There is a controversy between Mill and Whewell as to the nature of Colligation, and its relation to Induction proper. According to **Whewell,** Colligation is the same as Induction. **Mill** holds that Colligation should not be confused with Induction for the following reasons:

(i) In Colligation there is *no inference*.

Firstly, in Colligation, *three is no inference at all.* Certain facts are observed and brought together under a notion which we already possess. The navigator already possesses the notion of an island and he brings together the facts observed under this notion He does not make an inference from facts observed to facts unobserved. In Induction, on the contrary, we observe certain facts, and pass on to a general proposition comprising facts observed as well as facts unobserved.

(ii) Colligation *does not* explain facts but merely describes them.

Secondly, in Colligation we merely *describe* observed facts, while in Induction we further seek to *explain* them. In Induction we do not merely say that men *are* mortal but explain *why* they are so, by proving a causal connection In Colligation, there is no attempt at explanation by proving any connection amongst facts observed.

Hence Mill concludes that Colligation may be a "process subsidiary to Induction" or "a necessary preliminary to Induction" but Induction is something more than Colligation. *"Induction is Colligation but Colligation is not necessarily Induction".*

(iii) Colligation is sometimes deductive.

It may be pointed out that the two illustrations of Colligations, given above, are in some respects different. In the first illustration the navigator observes *all* the points of the boundary line, while in the second illustration, Kepler observes only *some* of the positions occupied by the planet Mars. **Mill** however says that

"there is..............no difference in kind" between these two cases. **Bain** says that the second case is, in fact, a *deduction*. "The positions of the ellipse supplied the major premise of the reasoning. Kepler's observations supplied the minor premise, they showed that the places of Mars coincided with the places in an ellipse; whereupon whatever was true of the ellipse was true of the orbit of Mars."

Sec 5. Inductions proper.

"**Inductions proper**" may be sub-divided into (A) Scientific Induction; (B) Unscientific Induction or Induction per Simple Enumeration or Imperfect Enumeration, and (C) Argument from Analogy, or simply, Analogy. It may be noted that some writers use the word 'Induction' to mean 'Scientific Induction' only. In their opinion, "Unscientific Induction" and "Analogy" are **Processes allied to Induction**, i.e., processes of reasoning which no doubt resemble Scientific Induction in some respects, but fall short of it.

A. SCIENTIFIC INDUCTION.

This has been fully explained in Section 2 of this chapter (See p. 9).

B. UNSCIENTIFIC INDUCTION or INDUCTION PER SIMPLE ENUMERATION.

Induction by Simple Enumeration is the establishment of a general real proposition on the ground of mere uniform or uncontradicted experience without any attempt at explaining a causal connection.

Induction by Simple Enumeration is generalisation, from uncontradicted experience

Bacon defines this process as "an induction because we have never found an instance to the contrary." **Mill** defines it as follows :—"*It consists in ascribing the character of general truths to all propositions which are true in every instance that we happen to know of.*" It is an argument from simple unanalysed experience, its formula being "*Such and such has always been found to be true, no*

Bacon.
Mill.

instance to the contrary has been met with; therefore, such and such is true".

Example—All ravens are black.

For example, so far as our experience goes, we have seen only black ravens. We have never come across a raven of any other colour, nor have we ever heard that any one else ever has. On the strength of this uniform or uncontradicted experience, we arrive at the general proposition—*All ravens are black* This is a general and real proposition based on observation of particular instances, and there is thus "an inductive leap" from the known to the unknown, but this leap is based on a loose application of the principle of the Uniformity of Nature, and not on the strength of a causal connection. We have not discovered or proved any causal connection between 'blackness' and 'ravens'; if we could do so, it would be an instance of Scientific Induction We believe, however, that the unobserved cases will be like the observed ones.

This form is known as Induction per Simple Enumeration, Unscientific Induction and Imperfect Enumeration

This form of Induction is Induction proper, because, there is, in it, "an inductive leap" from the known to the unknown, and it is this characteristic which constitutes the essence of Induction. But this Induction is *unscientific* or *popular*, because, there is no knowledge of any causal connection. It is called *Induction per Simple Enumeration*, because the conclusion is drawn on the ground of more enumeration or counting of instances. It is also known as *Imperfect Enumeration*, to distinguish it from the so-called *Perfect Induction* or *Induction by Complete Enumeration*, in which all the particulars coming within the sweep of the general proposition are enumerated.

Induction per Simple Enumeration is illustrated in all *popular generalisations.* The average man has neither the time, nor the inclination, nor the capacity, to undertake a scientific enquiry into the nature of things, involving, as it does, considerable patience and labour. He is often apt to reach hasty generalisations, and to run away with the idea that unthinking dogmatism, expressed with sufficient vigour, is a good substitute for patient and laborious enquiry. Thus, a foreign traveller who spends a few weeks in a strange land goes back to his native country to his own mind, a veritable sage, avails himself of a hospitable press, and airs his "impressions" about an alien people with the utmost confidence He talks glibly of men and women, of social customs and manners, of political institutions and religious practices, and even when such writings are not undertaken for propagandist purposes, they are scientifically worthless, and sometimes mischievous. In fact, the mischief is very great indeed, because, there is a modicum of truth in them, derived from fragmentary experience There is a basis in truth, because there is *some* experience. The foreigner comes across a shopkeeper who turns out to be a swindler, a hotel-keeper whose charges are out of all proportion to the quality of his bill of fare, and on the strength of these experiences which are true, *so far as they go*, the traveller, who is pressed for time, and yet anxious to spin out a connected presentable story, hastens to form general conclusions, which are indeed very far removed from truth.

Our popular generalisations are often inductions of this form.

Value of Induction per Simple Enumeration.

It has been said that the conclusions of Induction per Simple Enumeration are merely *probable*, while those of Scientific Induction are *certain*. According to **Bacon**, Inductions per Simple Enumeration have no importance whatsoever. As Bacon says: "Induction which proceeds by merely citing instances, is a *res peurilis*, a childish affair, and being without any principle of inference, it may be overthrown by a contradictory instance." Generally speaking, however, Logicians, while acknowledging that in a large number of popular

The conclusions of Induction by Simple Enumeration are merely probable.

generalisations, the severe condemnation of Bacon is just, have been content with merely saying that the conclusions of Induction per Simple Enumeration are merely *probable*, while those of Scientific Induction are *certain*. Probability, however, is a matter of degrees, ranging from what practically amounts to zero to what very nearly approaches scientific certainty. While it is true that the hasty and perfunctory generalisations of the man in the street are often worthless, it cannot be denied that the uncontradicted experience of all known men, in all the known parts of the globe, during all the known periods of history, during which it might be legitimately expected that contrary instances, if any, would have come to light, gives a very high degree of probability indeed.

Probability is a matter of degrees.

(a) The more the number of positive instances, the greater the probability.

(b) The absence of negative instances, when experience is of wide range, shows that the conclusion possesses a high degree of probability.

Fowler points out that the value of Induction per Simple Enumeration depends on *two* considerations —

(a) Firstly, "*the number of positive instances*, which have occurred to us" If the number of positive instances, which have occurred in our experience, be large, the value of the argument is comparatively high, while, if their number be small, its value is rather low. To use **Mill's** words "The precariousness of the method of Simple Enumeration is in an inverse ratio to the largeness of the generalisation"

(b) Secondly, "*the likelihood, if there be any negative instances, of our having met with them.*" When we have reason to suppose that were there any negative or contrary instances, they would have come to our experience, Induction per Simple Enumeration attains a high degree of probability. This appears to have been the view of **Aristotle** who suggests that if any one objects to a generalisation based on a well-grounded conviction that there are no contrary instances, it rests with the objector to find such instances

But the conclusions cannot be

It cannot be stated, too strongly, that *however, high the degree of probability, Induction per Simple*

Enumeration can never reach the certainty of Scientific Induction In Induction per Simple Enumeration, the strength of the conclusion depends on the *number* of positive instances observed, taking care that the area of experience is large enough to minimise the likelihood of meeting with contrary instances. In Scientific Induction, however, the number of instances observed is a matter of comparative indifference. In fact, it may even happen that in Scientific Induction, *the carefully tested observation of a single case may justify a general conclusion*, if a causal connection is established.

certain because a knowledge of causal connection is wanting.

In conclusion, it may be pointed out that Induction per Simple Enumeration may, in a large number of cases, be *the starting-point of Scientific Induction*. As **Grumley** puts it: "The chief value of the enumerative method lies in its power to suggest causal relation The condition that two phenomena (subject and predicate) are always or very frequently connected seems sufficient ground for entertaining the hypothesis that they are causally related. Inductive enumeration, then, is not altogether worthless from the scientific point of view; it is at least a valuable aid to induction proper."

It is the starting-point of induction proper

Induction per Simple Enumeration has been described as a form of Imperfect Induction. It is *imperfect*, because, no causal connection is *known* to exist It should be carefully understood that we do not *know* that there is a causal connection. Not that we know that there is no causal connection. If we *definitely* know that there is no causal connection, the inference of a general proposition cannot be justified at all. In Induction per Simple Enumeration, our mind is in a state of suspense. Moreover, though a *knowledge* of causal relation is wanting, we vaguely *believe* that there is some sort of a necessary connection A knowledge

In Induction per Simple Enumeration we do not *know* but we have a vague *belief* that there is necessary connection.

is wanting, but there is nevertheless a belief. For example, we do not know that there is any causal relation between 'blackness' and 'ravens.' Certainly, we do not know that there is no causal connection. We have no knowledge either way. If we know that there is no causal connection, we would at once discard the general proposition, and be content with the particular proposition—Some ravens are black. We would then realise that blackness in ravens is a mere "accident." But since we do not know that there is no causal connection, we arrive at the general proposition—All ravens are black—on the strength of a *belief* that there is some essential connection between the two. In course of time, with further extension of scientific knowledge, the vague belief will either ripen into knowledge or be discarded as baseless. If a causal connection comes to be discovered, the Induction per Simple Enumeration is elevated to the rank of a Scientific Induction. Thus, Induction per Simple Enumeration is in a state of unstable equilibrium. Either it must ultimately perfect itself into Scientific Induction or be degraded into a mere particular statement.

Note. Enumerative Induction: Complete Enumeration and Simple Enumeration.

Enumerative Induction

The expression "ENUMERATIVE INDUCTION" means generalisation on the strength of mere *enumeration* or counting of instances, as distinguished from Scientific Induction, in which there is generalisation, on the strength of a causal connection.

may be complete

Enumeration may be *complete*, in which we count *all* the instances coming within the sweep of the universal proposition. This is *Perfect Induction* or Induction by Complete Enumeration.

or incomplete.

Enumeration may be *incomplete*, in which we count a number of instances, and finding that they agree in possessing some common attribute, we conclude that other instances which do not come within our experience will also possess this attribute. This is *Induction by Simple Enumeration* or Unscientific Induction or Imperfect Enumeration.

Thus, when Scholastic philosophers divide Induction into Perfect and Imperfect, they may be said to have regarded Induction as resting on more enumeration or counting of instances, whether complete or incomplete.

It has been pointed out by modern Logicians that if Induction consists in mere enumeration, whether complete or incomplete, it can never reach the certainty of Scientific Induction. So far as Imperfect Enumeration is concerned, the enumeration is admittedly incomplete, and it is clear that "if counting alone is the process involved, the investigation ends where the counting ceases" We have no right, for instance, to assert on the basis of mere enumeration, that "since three-fourths of the apples in a barrel are ripe, all are ripe." Hence, Imperfect Enumeration can never give us certainty. It is claimed, however, that if enumeration be complete, as in Perfect Induction, the conclusion is certain. This is the view of JEVONS who maintains that Perfect Induction gives a certain conclusion, and goes to the opposite extreme in holding that the conclusions of Scientific Induction are not certain But the majority of modern Logicians points out that this view is entirely misconceived Scientific Induction is based on a knowledge of causal connection which alone can guarantee certainty while a mere counting of instances, even when complete, can only justify the conclusion that things *do happen* in a particular way *and not* that things *must happen* in that way To express this idea in a different language, we may say that enumeration at its best can furnish assertory conclusions, but never certain conclusions, while Scientific Induction alone can justify certain conclusions.

Enumerative Induction can never yield certain conclusions.

C. ARGUMENT FROM ANALOGY.

Analogy.

"Analogy" is the name of another mode of argument of an inductive character, not amounting to Scientific Induction. This will be treated to exhaustively in Chapter VI (p. 217).

Sec. 6. The Method of Induction or the Inductive Procedure—its different steps or stages.

The question is—What is the Method of Induction? What is the procedure which we should

What are the steps through

which we must pass in order that we can establish a general proposition on an observation of particular instances?

follow in order that we can establish a general law on the basis of particular experiences? The progress from particular facts to general laws involves the discovery and proof of a causal connection, and as the phenomena found in Nature are often highly complex, this may be a long, slow and tedious process How then would we proceed to detect a causal connection among the phenomena of nature?

The stages of the process:—

Logicians have recognised certain well-defined steps or stages in our progress from particular facts to general laws, though they are not agreed as to the importance which should be attached to each of these different stages. [P 42] Broadly speaking, there are the following well-marked stages, *viz.*, *Observation* (including Analysis and Elimination), *Formation of a Hypothesis*, *Generalisation* and *Verification*

1.—Observation, including Analysis and Elimination by Varying the Circumstances.

The first stage in the inductive enquiry consists in **Observation.***

We clearly ascertain the nature of the phenomenon to be studied, *i.e.*, *define* it.

Now, Observation is well-regulated perception, *i.e.*, perception of circumstances for a certain definite purpose Hence, before Observation proper begins, we should have an idea as to what the fact is which we seek to explain. In other words, it is necessary that we should *define the phenomenon*, *i.e.*, ascertain what the phenomenon is Hence Observation presupposes **Definition.**

Then begins Observation proper Observation supplies us with the materials of Induction We

* 'Observation' is here used in a wide sense to include Experiment also (See Ch III)

take note of the circumstances which are associated with the phenomenon under investigation. We note the circumstances which precede, accompany and follow the phenomenon in question, not in a haphazard or capricious manner, but patiently and with perseverance, according to a definite plan or purpose.

As Observation is undertaken for a definite purpose, it necessarily involves Analysis and Elimination.

Complex facts are *analysed or* separated in order that we may understand which of them are essential and which merely accidental.

Analysis *means breaking up a complex fact into its constituent factors* The facts observed in Nature are often of a complex character. Hence, in order to determine the cause or the effect of a particular phenomenon, we must resolve the complex facts into their simple constituent factors so as to ascertain which of these factors are essential, and which are merely accidental and irrelevant Thus, Analysis reveals that some factors of the complex whole are merely accidental and irrelevant, having no bearing on the subject-matter of investigation, while others are essential factors, relevant to the enquiry.

Accidental factors are *eliminated* or excluded

The next step is **Elimination.*** Elimination means *exclusion or rejection of accidental and irrelevant circumstances,* as distinguished from essential circumstances which point to a causal connection. **Mill** defines Elimination as "the successive exclusion of the various circumstances

* It may be pointed out that the word 'Elimination', in its ordinary usage, means 'setting aside as being of no importance' or 'discarding from consideration as being non-essential' but both Mill and Bain have sometimes used the word also to mean the process of singling out a causal circumstance This use of the word is improper.

which are found to accompany a phenomenon in a given instance, in order to ascertain what are those among them which can be absent consistently with the existence of the phenomenon". It is quite clear that Elimination presupposes Analysis. When Analysis reveals that certain circumstances are essential, and others are merely accidental, we proceed to eliminate the accidental circumstances, in order that we may concentrate our attention on those which are relevant to the issue.

by taking a number of instances, *i.e* by *varying the circumstances* under which the phenomenon occurs

Analysis and Elimination require what **Bacon describes as "Varying the Circumstances".** This means that we observe different sets of circumstances under which the phenomenon under investigation occurs. Nature is often highly complex, and facts are presented to us in a state of confusion. Failing to study the phenomenon under investigation by itself, *we collect by means of Observation various combinations of circumstances under which the phenomenon under investigation is found to occur* Hence, in order that Analysis and Elimination may work, we must adopt the process of *varying the circumstances*, so that different combinations in which the phenomenon occurs are successively presented to us, and we conclude that those circumstances which are constant, are essential circumstances, whereas, those which are sometimes present but sometimes absent are merely accidental.

Thus we *define* the phenomenon under investigation, *serve it under varying circumstances*, *analyse* these circumstances with a view to *eliminating* those which are accidental, so that we may *isolate* those which are essential to the purpose in view. Hence Observation involves *Definition*, *Analysis* and *Elimination* by *Varying the circumstances*.

According to **Bacon**, this is the most important step in the inductive method.

II.—Formation of a Hypothesis.

We next proceed to frame a hypothesis or a supposition as to what the cause of the phenomenon may be. This framing of a hypothesis requires a stroke of insight or creative genius.

We frame a hypothesis

A *hypothesis means a provisional supposition.* At first it may appear that several explanations of the phenomenon under investigation are *possible.* The *real* explanation is to be sought for among these possible explanations. In order to determine what the real explanation is, we fix upon one of the possible explanations for further investigation and this is what is called *"framing a hypothesis"* That which appears to be the most probable is provisionally selected for further investigation, and others are rejected or held in reserve

According to **Whewell**, the framing of a hypothesis is the most important stage in the inductive process.

III.—Generalisation.

We next arrive at general proposition

The next step is *Generalisation or inference of a general proposition on the observation of particular instances.*

When we find that a particular hypothesis explains the phenomenon under investigation in several instances, we infer that it will be an adequate explanation in all similar cases—that it will explain the phenomenon in all cases and under all circumstances. This Generalisation is made possible *by the employment of the Experimental*

Methods which enable us to establish a causal connection when it is already suggested by a hypothesis.

According to **Mill**, Induction is complete at this stage of generalisation.

IV.—Verification.

Verification means examining whether the general proposition which is arrived at is really true by appealing to facts.

The general proposition which we arrive at is next adopted as the basis of further investigation with a view to determining whether it explains other similar cases. If it be found to be unsatisfactory, it is discarded in favour of another hypothesis, and the process of investigation begins anew; if, on the other hand, it is *verified*, i.e., *found to be the correct explanation of the phenomenon under investigation*, it is raised to the dignity of a law. Thus *Verification converts a general proposition into a Law.*

Fowler defines Verification as follows: "Verification is not a distinct mode of proof, but simply a confirmation of one proof by another, sometimes of a deduction by an induction, sometimes of an induction by deduction, sometimes of one induction or deduction by another. The term is not infrequently used to designate simply the confirmation of a hypothesis by an appeal to facts."

It involves deducing consequences from the general proposition; and examining whether they agree with actual facts.

Verification may be *direct* or *indirect*. In Direct Verification, we directly observe facts while Indirect Verification involves *two* stages, *viz*, Deduction from the general proposition, and Testing the Deduction. In order to ascertain whether the general proposition is a correct explanation of the phenomenon under enquiry we may deduce consequences from it. This is called *Deduction from the general proposition.* Having deduced certain consequences, we proceed to compare our conclusions with actual facts. This process is called *Testing the Deduction.* If the conclusions agree with the actual facts, the general proposition is verified and is elevated to the rank of a scientific law; if, on the other hand, it does not agree with the actual facts, it must be set aside in favour of another supposition.

According to **Jevons**, Verification is the most important stage in the inductive process, and the

general proposition established at the previous stage cannot be said to be an Induction unless it is verified.

Illustration

Let us attempt to illustrate the application of the Inductive Method in its different stages, outlined above, with reference to a concrete instance of scientific enquiry. Suppose a scientist wants to find out the *cause of a particular disease, say, Malarial fever.*

To start with, we *define* what malarial fever is. Before any investigation is undertaken, *we must have an idea* of what we seek to explain. It may be necessary at a subsequent stage of the enquiry to modify our first conception, but, certainly, it is necessary that we should not have any confused idea of what we are going to enquire about. We note its symptoms, *viz.*, high temperature, pain in the head, rigor when the attack begins, a thirst for water, nausea and other symptoms. When it is thus defined, *Observation proper* begins It is observed that persons of different ages, of different habits, living in different places, under different climatic conditions, in different seasons of the year, are subject to the attack of this disease We attempt to observe conditions and circumstances which precede, accompany and follow the attack of the disease, we observe what different places are visited by the person suffering from an attack of this fever, what food he eats, what his habits of life are, what clothes he wears, what the peculiarities of his physical constitution are, and so on; we take good care that the field of our investigation is sufficiently large so that we may observe the phenomenon under all possible conditions. In other words, we *vary the circumstances* and observe cases of this fever in different sets of circumstances. Then we *analyse* the conditions we have observed in order to ascertain what the relevant conditions are, and what conditions are merely accidental. For instance, we observe that the question of age is not essential as persons of different ages are subject to attack; similarly, the food he eats is an irrelevant factor. In this way, we *eliminate* the accidental circumstances, and attend to those circumstances which appear to have some bearing on the question.

Next we proceed to *frame a hypothesis, i.e*, make a supposition as to the possible causes. This disease may be due to some bacilli absorbed through our food

or drink or breathed through the nostrils, or the infection may be carried by insects, such as flies or mosquitoes or bugs These and others are the possible explanations

For the purpose of further investigation, one of these suppositions, which appears to be most probable for the time being, is adopted Suppose we adopt the *hypothesis* that the infection is carried by mosquitoes. We then *generalise i.e.,* arrive at the proposition—All cases of malarial fever are due to mosquito-bite We next attempt to *verify* this general proposition, and this is to be done by deducing consequences from it, and then attempting to test the same by an appeal to facts. If mosquitoes be the medium through which the germs of the disease are carried, then it would follow that those persons who habitually use mosquito-curtains would be less subject to attack than those who do not. When we find that this conclusion is actually confirmed by further observation, the general proposition is verified to that extent It is further verified when we find that people, living in places where mosquitoes abound, are more frequently subject to attack than people who live in other places Further observation proves that some species of mosquitoes are harmless whereas, Anopheles are the real carriers, and hence the original supposition is accordingly modified In this way when verified, the general proposition is raised to the status of the inductive law—Anopheles are the cause of malarial fever

Relative importance of the different stages of the Method of Induction.

Logicians are divided in their opinion as to which stage is the most important in the inductive process Bacon Whewell

Though writers on Logic are agreed that there are certain well-defined steps in our progress from particular facts to general laws, there is difference of opinion as to what importance should be attached to the different stages. **Bacon,** for instance, lays great stress on the stage of Analysis and Elimination by Varying the circumstances, and fails to appreciate the importance of the subsequent stage of framing a hypothesis (See p. 62). **Whewell,** on the other hand, emphasises the importance of framing a hypothesis, while he devotes much less attention to the subsequent stages According to Whewell, Induction is nothing but "Colligation," *i.e.,*

binding together a number of observed facts by means of a suitable notion. Hence, according to Whewell, when the hypothesis is framed the work of Induction is practically complete. **Mill,** on the contrary, practically ignores the stage of the framing of a hypothesis. According to Mill, Logic is concerned with Proof, rather than with Discovery, and the framing of a hypothesis is concerned with Discovery Hence, according to Mill, the stage of generalisation is the all important stage in Induction, and Induction is nothing but "the process by which we conclude that what is true of certain individuals of a class, is true of the whole class, or that what is true at certain times, will be true in similar circumstances at all times" It is true that the stage of framing a hypothesis does not lend itself to a systematic and methodical treatment. Framing of Hypothesis is practically a matter of inventive genius which cannot be taught or explained. But to say that Logic is not concerned with discovery at all is to take an extreme and narrow view of the meaning of the term "discovery", because a truth cannot be said to be fully discovered, until it is thoroughly verified Besides, it may be pointed out that Mill himself is not quite consistent in his view because, he defined Induction as "the operation of *discovering* and proving general propositions". **Jevons,** again, maintains that the stage of Verification is the most essential stage in Induction He attaches the greatest importance to the verification of the generalisation, showing that the conclusions deduced from the latter conform to actual facts. Thus, Jevons takes away the importance of the process of generalisation, and makes Deduction, in the form of verification, the fundamental kind of reasoning.

Mill.

Jevons.

In conclusion, it should be pointed out that Logicians have drawn a distinction between the *Pure Inductive Method,* which stops at the stage of generalisation, and *the Complete Method* of scientific investigation which necessarily includes Verification. This Complete Scientific Method is what has been called by **Mill** "the Deductive Method", while **Jevons** calls it "the Combined or Complete Method," combining both Induction and Deduction This will be fully treated of in Chapter VII, p 231

The Complete Method.

Note. Conditions of Inductive Inference.

Twofold condition:

Conditions of Inductive inference are twofold, *viz.*, *subjective* (or mental or psychological) conditions and *objective* (or logical) conditions.

(i) Objective

In Section 6 we have fully dealt with the objective or logical conditions They are. (1) Observation, including Analysis and Elimination by Varying the circumstances; (2) Formation of Hypothesis, (3) Generalisation, and lastly, (4) Verification

(ii) Subjective

But there are certain subjective or mental conditions which are necessary in order that we may arrive at a general proposition on the evidence of particular instances. We shall briefly mention them

(a) Freedom from prejudices.

(a) At the very threshold of the inductive enquiry, the mind must be cleared of all prejudices and false conceptions **Bacon** calls them *idola,* i e. "idols". or fallacies. To use the language of Bacon, we must *interpret and not anticipate Nature.* Anticipating Nature means imposing our own presuppositions on Nature We must begin the study of Nature with an open mind, and observe phenomena as we find them, instead of reading into them our own ideas

(b) Patience and Perseverance.

(b) Patience and Perseverance are other mental conditions which are essential in order that a general law can be discovered and proved on an observation of particular instances. Nature is full of complexities, and natural phenomena are often found in a state of confusion A man who runs would not glean from Nature her secrets A vast amount of patience is necessary in order that the mysteries of Nature may be laid bare, and the inner unity underlying innumerable varieties of natural phenomena may be revealed.

(c) Belief in Uniformity.

(c) Lastly, there must be a belief or faith in the Uniformity of Nature and the Law of Causation These are fundamental principles or assumptions, and unless we believe in the truth of these principles, we cannot pass from the known to the unknown, and, establish a general proposition.

Sec. 7. Relation of Induction to Deduction.

It is usual with Logicians to classify Inferences into Deduction and Induction In **Deduction,** the premises

are assumed to be true, the conclusion follows necessarily from the premises, and cannot be more general than the latter. In **Induction**, on the other hand, the premises are particular facts of experience, the conclusion is a general proposition, and must not only be formally but also materially true. Thus we may notice the following **points of difference** between Induction and Deduction:

Points of difference between Induction and Deduction.

(a) Firstly, *in Deduction, the premises are assumed to be true, while in Induction, the premises are derived from experience.*

(b) Secondly, *Deduction aims merely at Formal Truth, while Induction aims at Formal and Material Truth.* In Deduction, the only question is whether the conclusion follows necessarily from the given premises, while in Induction, there is the further question whether the conclusion is true as a matter of fact.

(c) Thirdly, *in Deduction, the conclusion cannot be more general than the premises.* The conclusion may be as general or less general, but cannot be more general, than the premises, *while in Induction, the conclusion is always more general than the premises.*

Illustrations.

Illustrations. In the following syllogism,

All men are mortal
All kings are men
∴ All kings are mortal.

the premises are assumed to be true, the conclusion is obviously less general than the major premise, and the only question is whether the rules of syllogism have been observed. In the following inductive inference,

A is mortal
B is mortal
C is mortal
∴ All men are mortal

the premises are supplied by experience, the conclusion is more general than the premises, and is true as a matter of fact.

Two Questions.

As to the relation between Induction and Deduction, there is a twofold controversy: *firstly*, Is any

one of them more fundamental than the other? and *secondly*, Is any one of them prior to the other?

(1) Is Induction more fundamental than Deduction or *vice versa?*

With regard to the *first* question **whether Induction or Deduction is the more fundamental of the two**, extreme views have been held by Formal and Material Logicians. **Formal Logicians** e.g., **Hamilton, Mansel, Whately** etc., maintain that Deduction is the fundamental process, and altogether deny the claim of Induction to be regarded as an independent process of reasoning. According to this school of thinking, Induction is in essence deductive in nature, and can be expressed in the form of a syllogism. (See Sec. 9.) **Material Logicians** e.g., **Mill, Bain** etc., on the other hand, go to the opposite extreme, and maintain that all inference is at bottom inductive, and Deduction is merely a partial and accidental stage in the inductive process, that Deduction merely 'interprets' the general proposition established by Induction. It may be pointed out that these contending schools overstate the importance of one aspect of the question at the expense of the other. Induction and Deduction stand for two different aspects of the inferential process, and none of them can be resolved into the other.

(2) Is Induction prior to Deduction or *vice versa.*

With regard to the *second* question (which is to some extent connected with the first) viz., **whether Induction is prior to Deduction, or Deduction is prior to Induction** Mill and Jevons take opposite sides. According to **Mill,** *Induction is prior to Deduction.* Induction first discovers and proves general propositions, and then Deduction extends these general propositions to new cases. In a syllogism, which is the typical form of deductive reason-

ing, there must be at least one universal proposition in the premises. This universal proposition, which is assumed as a premise in Deduction, is the result of a prior Induction. Induction supplies the premises of Deduction, and must therefore precede the latter. According to **Jevons**, on the other hand, *Deduction is prior to Induction* The general proposition is first suggested to the mind as a hypothesis or a provisional supposition, and the stage of Induction is reached only when this hypothesis is verified. Now a hypothesis can be verified only when we *deduce* consequences from it, and examine whether the consequences actually agree with facts. Thus Verification involves Deduction From this standpoint, it follows that Deduction, as involved in Verification, precedes Induction. This controversy is really due to the fact that while Mill thinks that Induction is complete at the stage of generalisation, Jevons maintains that the generalisation must be verified before we may be said to have reached Induction There are several well-marked stages in the Inductive Method viz , Observation, Framing of Hypothesis, Generalisation, and lastly, Verification. If Induction be held to be complete at the stage of generalisation, Mill's view is correct; if on the other hand, there can be no true Induction till the generalisation is verified, Jevons' view is correct. The question of relative priority of Induction or Deduction is, however, futile when we remember that they are two aspects of the same inferential process in which we may start from the one or the other according to our purpose.

The relation between Induction and Deduction has sometimes been described by saying that

Induction and Deduction are

converse processes

Induction and Deduction are converse processes. Thus Induction proceeds from the particular to the general while Deduction proceeds from the general to the particular. In Induction we pass from facts to laws, while in Deduction we proceed from laws to facts. **Bacon describes Induction as an ascending process, and Deduction as a descending process.** These statements are misleading in so far as they suggest that Induction and Deduction are two distinct *kinds* of inference It is not at all correct to think that there is any opposition in principle between inductive inference and deductive inference.

Induction and Deduction are not two opposed kinds of inference. They merely differ in starting-point and procedure

but they are based on the same principle, *viz.*, that of connecting parts with the whole

The correct position regarding the relation between Deduction and Induction is this · Induction and Deduction are not two *kinds* of reasoning which are distinct and independent of each other, but that the starting-point and mode of procedure of the one are different from those of the other In short, **"Induction and Deduction differ in their starting-point, not in their principle."** The *starting-point* is different in the two processes, in Deduction we start with general principles, while in Induction, we start with facts of observation The *procedure* is also different; in Deduction, we proceed from the general principle to its consequences, while in Induction, we proceed to discover a general principle in particular facts But in *principle* they are the same, in other words, the real process of inference is in each case the same. The essence of inference consists in the fact that it exhibits the manner in which particular facts are connected together into a system or whole In other words, Inference always implies an effort on the part of the mind to see how parts are related to

the whole *i.e.*, particular facts are related to the general law. This end is achieved by both Induction and Deduction. In carrying out this purpose the mind begins with the knowledge it already possesses *e.g.*, Deduction starts with general laws while Induction starts with particular facts. But from whatever point we set out, and whatever may be our immediate object, the result is the same in both cases *viz.*, an insight into the connection of facts according to some general principle.

Induction and Deduction are supplementary processes.

In achieving their ultimate object, *Induction and Deduction supplement each other.* In actual reasoning, involving some degree of complexity, we often employ both. A doctor observes that several patients suffering from malarial fever are cured by the administering of quinine, and establishes the general proposition—In all cases quinine cures malarial fever; subsequently he makes use of this general principle in treating a new patient. Thus Induction and Deduction are complementary and correlative processes.

Welton.

We sum up the discussion with a quotation from **Welton:** "There is no opposition between deductive and inductive reasoning .... But there is, nevertheless, a distinction of aspect between induction and deduction. In induction, reality presents itself in concrete and partially isolated instances, and the task of inference is to [illegible] universal which is more or less hidden in those [illegible]. In deduction on the other hand, reality presents itself in its universal aspect, and the task of inference is to trace the presence of that universal in the differing and complex instances of its manifestations. The distinction is, therefore, solely one of the order in which the two aspects of reality are presented to us, and this difference can have no effect upon either reality itself or our final conception of it, when we know it in both its aspects"

Note. Certain Expressions descriptive of the nature of the relation between Induction and Deduction.

I. Jevons: Induction an "Inverse Process."

Jevons.

According to Jevons, Induction is simply an *"inverse process;" the inverse of Deduction.* As he puts it: "Induction is, in fact, the inverse operation of Deduction, and cannot be conceived to exist without the corresponding operation." (*The Principles of Science*—Ch VII) This description seeks to emphasise that Deduction is the prior process, and Induction is merely the inverse of it. The expression 'inverse process' presupposes a 'direct process'.

The meaning of the term "inverse process" in mathematics.

The terms "direct process" and "inverse process" have been borrowed from Mathematics. A direct process is one by which, given certain data and the laws of inference, we arrive at a conclusion; the inverse process is one by which, given the conclusion, we attempt to get back to the data. The direct process yields a definite result, while the inverse process may yield very indefinite results. To take an example of the direct process: given 4×4, the product is 16. The conclusion is definite. To take an example of the inverse process: given the product 16, we ask the question—of what factors is 16 the product? The answer is indefinite—may be 4×4, 2×8, and so on.

It is suggested that the conclusions in Induction are uncertain.

By describing Induction as an "inverse process," as contrasted with Deduction, which is regarded as a "direct process", some Logicians seek to convey the idea that *the conclusions of Deduction are definite, while those of Induction are indefinite.* For example, from the premises "All M is P' and 'All S is M', the conclusion 'All S is P' definitely follows. But supposing the conclusion 'All S is P' is given, we cannot say definitely from what premises it was obtained. Deduction passes from causes to effects, if the cause be known the effect definitely follows from it. In Induction, however, we pass from the effect to the cause, it is suggested that for any given effect there may be a number of causes.

The description of Induction as an "inverse process" is misleading It conveys the impression that Induction necessarily reaches indefinite results. But this is certainly not true. The aim of Induction is to discover and prove a causal connection, and when that is done, its conclusions attain definiteness and certainty. When the true causal connection is discovered, we can not only pass from the cause to the effect but also from the effect to the cause.

The description is misleading.

II. Bacon describes Induction as an ascending process, and Deduction as a descending process.

Bacon.

Induction is called "the ascending process" while Deduction is called "the descending process."

The meaning sought to be conveyed by this description is this. A man who is climbing a hill has to undergo considerable trouble and effort, but when he reaches the top of the hill, he is in command of all things which can be surveyed from that height Similarly, in attempting to establish a general proposition, we have to undergo considerable labour, but once a general proposition is reached, we are in command of all the particulars comprising the general proposition. Again, in descending from the hill-top, we are in a state of comparative ease. So in Deduction, the application of a general principle to particular cases is a comparatively easy matter. Hence it is described as a descending process.

III. Fowler describes Induction as proceeding from effects to causes, and Deduction as proceeding from causes to effects.

Induction proceeds from effects to causes while Deduction proceeds from causes to effects

The meaning of this description is that in Induction, the effect is given and we try to find out its cause, while in Deduction, the cause or the supposed cause is given and from this we proceed to find its effect.

This description, however, takes a narrow view of Induction In Induction, we not only reason from effects to causes, but sometimes also from causes to effects. For instance, supposing a scientist wants to know the effect of introducing a poison into the body of an animal. The poison is injected, and it is found that it causes death. This is Induction as to the effect of a given cause.

Buckle:

IV. Buckle says that in Induction, we reason from facts to ideas, and in Deduction, from ideas to facts.

In Induction, we reason from facts to ideas while in Deduction, we reason from ideas to facts

This description signifies that Induction means generalisation from facts observed, while Deduction means specialisation of the general law in individual cases. The establishment of a general proposition involves more of the mental factor than what is involved in the knowledge of facts, and hence it is described as an "idea" in contrast with what is involved in merely observing facts. Of course this description should not be taken as strictly true because, even in merely observing facts, the mental element is not wholly absent

Sec. 8. Use, Importance and Necessity of Induction.

Uses of Induction —

In dealing with the importance of Induction, we may point out that it has the following uses:—

(i) Induction supplies the general premises of Deduction

(*i*) *Induction supplies the universal premise or premises of Deduction.* In Deduction, we argue from the general to the particular, or from the more general to the less general In Deduction, these general propositions are assumed to be true, and it is for Induction to prove their ... Only a limited number of general truths is assumed as axioms or postulates without proof but the vast majority of general propositions is established by Induction

(ii) Induction establishes Material Truth

(*ii*) The aim of Logic is Truth, in the full sense of the term, including both Formal and Material Truth. Deduction, however, can only prove Formal Truth, and *Induction is necessary in order that Material Truth may be established.*

(iii) Induction helps future investigations

(*iii*) *Induction,* by discovering and proving general laws governing phenomena, ***helps us in our future enquiries.*** When a law is established, it becomes the starting-point of future investigations.

(iv) Induction reveals the inner Unity of Nature.

(*iv*) *Induction reveals the inner unity and harmony of the universe.* At first sight, Nature appears to be a chaos, but Induction by discovering and proving laws governing the phenomena of Nature proves that Nature is not really a chaos but a cosmos

The importance of Induction has led certain thinkers to hold that it is the only true method, but the true logical method is a combination of Induction and Deduction. [P. 231].

Sec. 9. The Inductive Syllogism

From the time of Aristotle, various attempts have been made to bring Induction under the Syllogism. Let us consider these attempts at some length

I. The Inductive Syllogism of Aristotle.

According to **Aristotle,** Induction is "a syllogism by which we prove the major term to be true of the middle term by means of the minor term," or more simply, **"Induction is proving the major term of the middle by means of the minor."**

In Induction we prove the major term of the middle by the minor.

In this definition, the expression, "major term", "minor term", and "middle term" are not used in their usual meaning Here "major", "middle", and "minor" refer to the *varying width of the denotation of the three terms, i.e.,* the "major term" is that which has the widest denotation; the "minor term" is that which has the least denotation; and lastly, the "middle term" is that the denotation of which is greater than that of the "minor term," though less than that of the "major term."

Aristotle uses these expressions in a special sense.

TO TAKE ARISTOTLE'S EXAMPLES :

Example.

Symbolical.

S_1, S_2, S_3, are P.

S_1, S_2, S_3, alone are M.

∴ All M is P.

Concrete.

Man, Horse, Mule, etc , are long-lived.

Man, Horse, Mule, etc , are *all* the bile-less animals.

∴ All bile-less animals are long-lived.

Here "P" or "long-lived" is called the "major term," having the widest denotation, "M" or "bile-less animals" is called the "middle term," because its denotation is narrower than that of the "major term," and supposed to be wider than that of the term "S_1, S_2, S_3," or "Man, Horse Mule, etc" Lastly, the term "S, S_2, S_3," or "Man, Horse, Mule, etc." is called the "minor term", because it is supposed to have the least denotation, not only less than that of the "major term," but also less than that of the "middle term" We shall, however, see later on that the denotation of the so-called "middle term" is the same as that of the so-called "minor term."

From the examples given above, we can understand Aristotle's definition of the Inductive Syllogism. In the symbolical example, P, the "major term" is proved of M, "the middle term" by means of S, "the minor term." In the concrete example, "the major term," "long-lived" is proved of the "middle term," "bile-less animals" by means of the "minor term," "Man, Horse, Mule, etc"

The principle of the Inductive Syllogism is the very opposite of the *Dictum de omni et nullo.*

It may be pointed out that the principle on which the Inductive Syllogism is based is the opposite of the principle of the Deductive Syllogism *viz.*, the *Dictum de omni et nullo.* This dictum lays down that whatever can be predicated (affirmed or denied) of the whole, can be predicated (affirmed or denied) of the parts The Inductive Syllogism of Aristotle, on the other hand, is based on the principle that *whatever can be predicated (affirmed or denied) of all the parts can be predicated (affirmed or denied) of the whole* In the concrete example, the major premise states that the attribute "long-lived" can be affirmed of "Man, Horse, Mule, etc," and the minor premise states that "Man, Horse, Mule, etc." are all the kinds of bile-less animals. Hence in the conclusion, we infer that what can be affirmed of all the kinds or species* of bile-less animals *separately*, can be affirmed of the whole class of bile-less animals

Aristotle's individuals are species.

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* It has been pointed out by some Logicians, *e.g.*, **Sigwart**, that Aristotle's "individuals" are not particular

From the above it is quite clear that the validity of this Inductive Syllogism depends on the question whether in the premises we have examined *all* the parts of the whole, and have not overlooked even one of the parts. The validity of the conclusion, "All bile-less animals are long-lived," depends on the question whether "Man, Horse, Mule, etc.," are *all* the parts of the whole class, "bile-less animals," and whether every one of them has been found to possess the attribute "long-lived". Hence *Aristotle's Inductive Syllogism is a representation in the form of Syllogism of what is known as Perfect Induction.* The universal proposition is established in the conclusion on a complete enumeration of all the particulars coming within its sweep. Thus this Inductive Syllogism has nothing to do with what modern Logicians call Scientific Induction. This has led certain Logicians to say that *Perfect Induction is syllogistic while Scientific Induction is not syllogistic* *

Aristotle's Inductive Syllogism represents Perfect Induction

Criticism.

On an examination of the so-called "Inductive Syllogism" of Aristotle, we find that it is not an ordinary syllogism at all. This Syllogism has the appearance of a syllogism in the third figure, because, the middle term is subject in both the pre-

The Inductive Syllogism, according to ordinary rules, involves the

individual things but species which he combines under a genus Hence the difficulty of complete enumeration of "individuals" is not felt by him. Aristotle thought that an exhaustive enumeration of all the species composing a genus was quite possible

* We shall, however, see later on that some Logicians have attempted to reduce Induction proper also into the form of a syllogism [P. 57]

fallacy of Illicit Minor.

mises. In the third figure, however, according to the rules of syllogism, the conclusion must be particular, and we cannot draw an A proposition in the conclusion even though both the premises are A propositions. From the combination AA in the third figure, we can draw the conclusion, I, in *Darapti.* Here, however, the conclusion is an A proposition Hence, judged by the rules of ordinary syllogism, the argument involves the fallacy of Illicit Minor.

But the conclusion is true, because, the minor term is distributed in the premise.

The conclusion, however, is true, because in the minor premise, the predicate (the minor term in its ordinary meaning) "all bile-less animals" is distributed, and there cannot be any objection to its distribution in the conclusion. In fact, the minor premise is not an ordinary A proposition, because an ordinary A proposition distributes its subject only, and not the predicate The minor premise is what **Hamilton,** in his doctrine of the Quantification of the Predicate, calls a U proposition, distributing both the subject and the predicate.* As **Stock** puts it: "This argument violates the rules of syllogism and yet it is perfectly valid. The reason of this is that the rules of syllogism are not designed to meet the case of a quantified predicate, such as we have in the second proposition."

It should not be thought, however, that Aristotle regarded this Inductive Syllogism as a kind of proof, distinct from Deduction. On the other hand, according to Aristotle, all strict proof is Deduction and the so-called Inductive Syllogism is "a mode of arranging a

* As in the minor premise, both the subject and the predicate are dist[illegible], they have the same denotation. Hence, the so-called "minor-term" of Aristotle, *viz.*, "Man, Horse, Mule, etc ," has *the same denotation* as the so-called "middle term" *viz.*, "bile-less animals "

deductive argument so as to enable us to realise psychologically the truth of the general principle, which is the real major premise—a mode of illustrating the principle by bringing forward instances."

II. The Inductive Syllogism of Aldrich and Whately.

Aldrich and Whately attempt to reduce Induction proper into a syllogism

The Inductive Syllogism of Aristotle is a representation of what is known as Perfect Induction or Induction by Complete Enumeration. The Inductive Syllogism given by **Aldrich** and **Whately**, however, is more ambitious, and is designed to include Induction proper To take the following example:

Example:

> The magnets which I have observed, *and the magnets which I have not observed,* attract iron
>
> These magnets are all magnets
>
> ∴ All magnets attract iron

But they assume the very thing which they want to prove.

It is argued that this inductive syllogism represents Induction proper, because, here, we establish a general proposition on an observation of *some* magnets only. The conclusion is not a mere summary of observed particulars, but is a true general proposition. But if we examine the major premise, we find *we assume the very thing which we seek to establish*—we take for granted that not only those magnets which we have observed, but also others which we have not observed, attract iron. Now, how are we entitled to make this assumption? How are we entitled to take for granted that the unobserved cases will be like the observed ones in this respect? This is the very problem of Induction, and Deduction cannot afford any explanation. As **Bain says:** "The major here obviously assumes the very point to be established, and makes the

Hence, this attempt fails.

inductive leap. No formal logician is entitled to lay down a premise of this nature. The process altogether transcends syllogism or formal logic."

Hence we conclude that Induction cannot be reduced to a syllogism in this way.

Mill.

III. Mill's Inductive Syllogism.

According to **Mill,** Induction necessarily involves a passage from the known to the unknown and this "inductive leap" has its justification in the *assumption* of the principle of the "Uniformity of Nature", *i.e.*, the assumption that Nature behaves in the same way under similar circumstances. This idea is expressed by Mill when he says that "*Every Induction may be thrown into the form of a syllogism by supplying a major premise*" and that "*if this be actually done the principle.........of the uniformity of the course of nature will appear as the ultimate major premise of all inductions.*" Thus, according to Mill, every induction can be reduced to a syllogism by supplying a major premise, which would be an aspect of the Uniformity of Nature, and that if we throw an inductive argument into a series of syllogisms, we shall arrive at an ultimate syllogism, which will have for its major premise, the principle of the Uniformity of Nature itself. For example:

The major premise of an Induction expressed as a syllogism, is a special form of Uniformity.

What is true of John, Peter etc., is true of all mankind.
John, Peter etc., are mortal
∴ All men are mortal.

The major premise in this syllogism is a special application of the principle of the Uniformity of Nature. "What is true of John, Peter, etc., is true of all mankind", because Nature is uniform in her

Ultimately the law of Uniformity itself becomes the

ways. In this way, if we throw the whole course of an inductive argument into a series of syllogisms, we shall ultimately arrive at a syllogism, the major premise of which will be the principle of the Uniformity of Nature itself, thus: major premise.

Under the same conditions, the same event will always follow

Under conditions, a, b, c, X is found to happen.

∴ Under conditions, a, b, c, X will always follow.

Thus, Mill concludes that **the principle of the Uniformity of Nature is the ultimate major premise of all inductive generalisations.** It should be pointed out that this view of Mill is in conflict with his other view that the law of Uniformity is itself a generalisation from experience (See p. 73).

APPENDIX.

History of the Inductive Method.

In Deduction, there is a large body of doctrines which has been more or less generally accepted in its most important features from the time of Aristotle. So far as the doctrine of Induction, however, is concerned, though there are traces in the philosophy of Aristotle and the Scholastic philosophers of the Middle Ages that they were not wholly unacquainted with it, yet their treatment is vague and rudimentary, and the modern conception of the scope and importance of Induction is a matter of comparatively recent growth. Let us briefly trace the development of Induction from the time of Aristotle. Induction unlike Deduction is of recent growth.

1. Aristotle (384—322 B.C.).

The term 'Induction' has come down to us through the Latin form *"Epagoge,"* a term used by ARISTOTLE. This is defined as "a process of ascending from the particulars to the universal on an examination of all the particulars." For example, we see that the skilful steersman is the Aristotle recognised Perfect Induction

best, the skilful driver is the best, and so on, therefore, we realise that the skilful man is the best in every occupation. In other words, we prove a statement about a whole class by reference to all the particular cases of it. Thus this Induction is equivalent to Perfect Induction.

Aristotle expressed this Induction in the form of a syllogism, in which *"we prove the major of the middle by means of the minor"* (See Sec 9 of this chapter). We have also seen that this so-called "inductive syllogism" is a representation of Perfect Induction, and is really deductive in character. [P. 55].

Induction proper was not unknown to him, he called it "proof from experience."

Now since Aristotle applied the name "Induction" to this mode of arriving at a universal proposition on an examination of all the particulars comprising it, and since he did not apply this name to any other method of arriving at a general proposition, some modern Logicians have erroneously thought that he recognised only Perfect Induction, and was not acquainted with Scientific Induction, in which we establish a general proposition on an examination of some particulars only. While it is true that the idea of Scientific Induction, in its fully developed form, is an achievement of modern Logicians, it is equally true that Aristotle was acquainted with the method of establishing general propositions on an examination of some particulars only The error appears to have arisen, because Aristotle did not call this method 'Induction.' The term employed by him to designate this method was *"experimentum"* or "proof from experience."

2. The Scholastic Logicians

The Scholastics were mainly concerned with enumerative Induction

The Scholastic Logicians of the Middle Ages, to use words of **Welton,** "made the essence of Induction to consist in enumeration". They divided Induction into Perfect and Imperfect, according as enumeration was complete or not

Induction though Induction proper was not unknown to them.

It may be pointed out, however, that though the Scholastics were mainly concerned with Enumerative Induction, there are unmistakable traces in their writings to show that the doctrine of Scientific Induction was not wholly unknown to them. Though it is certainly true that they did not realise the full significance of Scientific Induction and did not apply it with any success, yet

it was not unknown to them. Following Aristotle, they called it "proof from experience"

3. Bacon (1561—1626).

Bacon has been called the "Founder of the Modern Inductive Philosophy". He holds the Logic of the Scholastics to be entirely useless, and condemns them severely for not recognising anything other than Enumerative Induction. Bacon undertakes to remedy this defect by setting forth a new Inductive Method. He treats of this in his famous *Novum Organum* (or the New Instrument) contrasting it with the *Organon* of Aristotle.

Bacon—the founder of the Inductive Method.

Bacon's Inductive Method is entirely different from Induction by Simple Enumeration. According to him, "Induction which proceeds by Simple Enumeration is a *res puerilis* (a childish thing), and concludes uncertainly, and is exposed to danger from any contradictory instance, and for the most part pronounces from fewer instances than it ought, and of these only from such as are at hand. But the Induction which will be useful to the discovery and demonstrations of Sciences and Arts, ought to separate Nature by due rejections and exclusions, and then after a sufficient number of negatives, to conclude upon affirmatives."

Simple enumeration is a childish affair.

According to Bacon there are *three* steps in the inductive process —

Three steps —

(1) COLLECTION OF INSTANCES. Bacon says "A natural and experimental history must be prepared—sufficient and good." In simple language, it means that we must collect a large number of instances in which the phenomenon under investigation occurs.

(1) Collection of instances.

(2) SORTING OF INSTANCES. The facts collected by Observations are to be arranged in three Tables in an orderly manner.—

(2) Sorting according to three tables.

(a) The first table, called *the Table of Presence*, is to contain instances of the presence of the phenomenon which is the object of enquiry;

(b) The second table, called *the Table of Absence*, is to contain instances of its absence (though other-

wise allied to the instances where the phenomenon is present).

(c) The third table, called *the Table of Degrees*, is to contain instances in which the phenomenon under investigation is present in varying degrees.

These three tables subsequently formed the foundation of Mill's Methods of *Agreement, Difference, and Concomitant Variations,* though we would not suppose that Bacon realised anything like the precision of these methods.

(3) Elimination by Varying the circumstances.

(3) EXCLUSION OR REJECTION. After the collection of instances and the sorting of them under the three different tables, explained above, Induction, according to Bacon, proceeds by Exclusion or Rejection This is Bacon's method of Elimination by the Varying of Instances.

Bacon takes special credit for his process of Exclusion or Rejection As **Bain** puts it "Bacon contrasts it with the popular method of proceeding by Simple Enumeration, that is counting only the favourable instances, overlooking the unfavourable and he claims to be the first to make it prominent The problem of Induction being to find such a quality as is always present or absent with the given quality, and always increases or decreases with it, the first work of true induction is the rejection or exclusion of the several qualities, which are not found in some instances where the given quality is absent, or are found to increase in some instances where the given quality increases".

Bacon relies mainly on Elimination and neglects the part played by the human mind in Induction.

Thus the principal features of the **Baconian Method** are Analysis and Elimination by Varying the Circumstances. This is satisfactory so far as it goes, but it is not sufficient for the purpose of detecting the more difficult laws of Nature. Bacon advised that we should always begin by collecting facts, arranging them according to the points of agreement and difference, and gradually gathering from them laws of greater and greater generality. He condemned the process of "anticipating nature," *i.e.*, forming hypotheses as to what the laws of nature probably are, and seemed to think that systematic arrangement of facts would take the place of all other methods. On this view, he made extravagant claims for his method, holding that it would do for science what the discovery of the mariner's compass had done for

navigation It would put the intelligence of men on a footing of equality, and acquisition of knowledge would be purely a mechanical process. Bacon says plainly: "Our method is one which leaves not much to acumen or strength of wit but nearly levels all wits and intellects." Thus *Bacon neglects the part played by the mind in the acquisition of knowledge.* This is entirely erroneous, because, at every stage in Induction the mind plays an important part. Observation or collection of facts is not a random and accidental process, but must be selective. The mind selects what facts are to be observed and collected according to the purpose in view. Besides, Bacon fails to perceive that the formation of Hypothesis is a very important step in Induction, and the actual framing of a hypothesis is due to imaginative insight. Thus Bacon's method is insufficient for the purpose of Induction.

It has been pointed out that though according to Bacon, "the syllogism is not to be applied to the principles of science," *Bacon's method of Elimination is thoroughly syllogistic.* Bacon's Inductive Method can be reduced to the following Disjunctive-Categorical Syllogism:— The Method of Elimination is a deductive process.

The cause is either a or b or c or x.
It is neither a nor b nor c.
∴ It is x.

It is of course assumed that the alternatives a, b, c and x are exhaustive, and that the disjunction is complete. But it is this very assumption which requires to be proved, and which it is most difficult to prove. In fact, unless this is proved, the inference is invalid.

4. Newton, Herschel, Whewell.

The insufficiency of the Baconian method led scientists to formulate the true method of scientific investigation. In this connection, the names of Newton and Herschel may be mentioned.

NEWTON (1642-1727) was a mathematician and a physicist, and not a logician, but in his works he deals to some extent with the scientific method *Newton's method* Newton.

consisted of three steps, viz., Analysis, Formation of law and Synthesis. By the term "hypothesis", Newton understood premature assumptions made on altogether insufficient grounds, and these hypotheses were strongly condemned by him. In this sense, he said "*Hypotheses non fingo*" (I do not imagine hypotheses).

Whewell. HERSCHEL (1792-1871) in his *Discourse on the Study of Natural Philosophy* formulates Nine Rules of Philosophising, some of which were elaborated into Experimental Methods by Mill.

Herschel. WHEWELL (1794-1866) defines Induction as "Colligation of facts by means of an exact and appropriate conception". Whewell does not deal with Experimental Methods and according to him, Induction is a method of Discovery rather than of Proof, as it aims at discovering suitable concepts which would colligate or bind together particular facts of experience.

5. Mill (1806—1873).

The thinker who did most to put the study of Inductive Logic on a new basis was JOHN STUART MILL

Mill. Mill defines Induction as "the operation of discovering and proving general propositions", though, according to him, Induction is more concerned with Proof than with Discovery. Induction does not consist in enumeration, but in passing from the known to the unknown Hence, it relies on the principle of the Uniformity of Nature and the Law of Causation In order that a general proposition may be established Mill formulates his famous Experimental Methods, which are devices for proving causal connection among phenomena These will be dealt with in detail in Chapter V.

EXERCISE 1.

1. Determine the character of Inference and show how it is illustrated in Induction.

2 "Induction is legitimate inference from the known to the unknown" (p 12) "The Inductive hazard—the leap to the future" Examine the view of Induction implied in these statements.

3 "Induction is the legitimate inference of general laws om individual cases" Discuss.

4. What are the characteristics of a valid Induction? Explain and illustrate them fully.

5 Explain the meaning and scope of Scientific Induction, distinguishing it from processes which are improperly called Inductions. Illustrate your answer.

6 "In Perfect Induction there is no 'inductive leap' hence, there is no real inference." Discuss

7. Distinguish between Perfect and Imperfect Induction Is it true to say that Perfect Inductions have no scientific value whatever?

8 What are the marks of inductive inference? How does Induction differ from Colligation of facts?

9 Distinguish between Scientific and Popular Induction Which of them constitutes Induction proper, and why?

10 "All cases of reasoning in which the premise or premises are particular facts are cases of Induction;' accepting this as a definition of Induction, show from it what the chief kinds or forms of Induction will be and indicate the logical value of each giving examples

11. Distinguish clearly between Complete and Incomplete Induction Which of them constitutes Induction proper and why?

12 You draw an isosceles triangle on a board and prove that its two basal angles are equal and then draw the conclusion that all isosceles triangles have their basal angles equal, explain the logical character of this conclusion.

13 State, explain and illustrate the various kinds of Inductions improperly so-called. Explain clearly in each case why it is not an Induction in the proper sense of the word

14. Can we form a valid universal proposition about facts if we have not actually observed all the individuals signified by the subject of the proposition? If so, how?

[**Hints.**—Only in so-called Perfect Induction, we examine all the individuals signified by the subject of the universal proposition. In Scientific Induction, we arrive at a general proposition on an examination of some of the individuals signified by the subject of the universal proposition, on the strength of the laws of Causation and Uniformity of Nature In Induction per Simple Enumeration also we arrive at a really general proposition, on a vague application of the principle of uniformity.]

15. Discuss the question whether Perfect Induction is demonstrative and syllogistic while Imperfect Induction is neither

16 When is a single instance sufficient to warrant a universal conclusion? Are there cases where the greatest possible number of concurring instances without an exception is not sufficient to warrant a conclusion?

17 How would you distinguish between 'processes *simulating* Induction' and 'processes *allied to* Induction'? Explain and illustrate the different forms of each class. [P 15.]

18 What are the different processes that simulate Induction? Explain in each case why the process is not real Induction.

19. What are the conditions of proof for a general law inferred from an individual case? Illustrate by examples from mathematical and physical sciences. [P. 26.]

20. Explain and exemplify the process which Bacon called 'Inference from Simple Enumeration.' Explain in what its inferiority consists and how it differs from Scientific Induction.

21. "Enumerative Induction is simply based on the expectation that the future will resemble the past and is therefore of no scientific value" Discuss.

22. What is meant by "varying the circumstances" in scientific investigation? What is the use of this process? Give illustrations to show its use and necessity.

23 Exhibit the nature and use of the Inductive Method

24. Mention the conditions of Inductive Inference.

25. Explain fully the process of Induction and its aim.

26. Discuss the claim of Induction to be a separate department of Logic.

27. "Induction is the process of establishing general propositions and Deduction is the interpreting of them" Explain and illustrate this. Is the theory of reasoning here implied admitted by all logicians? If not, what other theory has been held?

28. Do you think that Mill and Bain are right in holding that all Deduction depends on previous Induction? Give your reasons.

29 Explain carefully the distinction between Inductive and Deductive reasoning

30. Discuss fully the question whether Induction precedes Deduction or Deduction precedes Induction.

31. Is Inductive Reasoning merely the converse of Deductive reasoning? Fully discuss this question and in this connection bring out clearly the relation of the one to the other.

32 Explain your view of the relation of Induction to Deduction. Which of these is the prior process and on what grounds do you think it to be so?

33 Compare the process of Induction with that of Deduction. State clearly wherein they differ.

34. "The difference between deduction and induction is not one of principle but of starting point." Discuss.

35. What is Induction? Can Induction be described as the inverse process of deduction?

36. Indicate and illustrate the aid given to Induction by Deduction.

37. Is Induction reducible to syllogistic reasoning? Argue the point fully. Examine the different attempts that have been made to resolve the former into the latter.

38 "The Aristotelian Inductive syllogism is really deductive." Explain the statement.

39 Show by a concrete example that Inductive inference admits of being thrown into the Deductive form.

40. Can an Inductive Argument be reduced to a Deductive one? Discuss.

41. Can the provinces of deduction and induction be kept completely separate?

42. Explain what sort of Logic is used to make the following statements.—

(a) The heat of June is followed by the refreshing showers of July

(b) Homer is the common property of all later poets.

(c) Plants must breathe in order to live

[**Hints.**—(a) This is Inductive reasoning. It is an example of Induction per Simple Enumeration, because so far as our experience goes, this has always been found to be true. This is based on uncontradicted experience.

(b) This is also an example of inductive reasoning in which we arrive at the general proposition on the strength of uncontradicted experience and as such, it is a case of Induction per Simple Enumeration.

(c) This is an inductive reasoning known as Argument from Analogy [This will be dealt with in Ch VI]

43 If the counting is incomplete, may we make the "inductive leap" concerning cases not investigated?

44 Give a statement of the general problem of Induction What precisely is the problem in understanding how the mind reaches universal truth?

45 'Induction is establishing general propositions'. Explain.

46. How do you distinguish between Inductive and Deductive Inference?

CHAPTER II.

GROUNDS OF INDUCTION—FORMAL GROUNDS.

a

Sec. 1. Grounds of Induction—Formal and Material Grounds.

In Induction there must be both Formal and Material Truth.

In Deduction, we are merely concerned with Formal Truth, *i.e.*, with the question whether the argument conforms to the laws of reasoning; *e.g.*, a syllogism is correct if it conforms to the general syllogistic rules. In Deduction, we are not concerned with the question whether the argument is also materially

true, *i.e.*, whether the materials with which the argument deals are true as a matter of fact. In Induction, however, there must not only be Formal Truth but also Material Truth. In the first place, the argument must conform to certain formal laws and thus be formally true; secondly, it must conform to the actual state of things and thus be materially true. Hence in Induction, we have both Formal and Material Grounds. Hence there are

The Formal Grounds of Induction are (1) *The Law of the Uniformity of Nature*, and (2) *The Law of Causation*. **The Material Grounds of Induction** are (1) *Observation* and (2) *Experiment*. In this chapter we deal with the Formal Grounds while the Material Grounds will be dealt with in the next chapter. Formal Grounds and Material Grounds.

Formal Grounds of Induction.

In Induction, we observe particular instances, and seek to establish a general proposition on the strength of these observations. The question is—What is the basis of this generalisation? Having observed that this or that fire burns, we generalise—Fire burns What right have we to do so? Logicians have maintained that the basis of generalisation lies in two presuppositions, *viz.*, (i) that Nature is uniform, and (ii) that every event must have a cause These presuppositions are respectively called the Law of the Uniformity of Nature and the Law of Causation

Sec. 2. The Law of Uniformity of Nature.

The Law of the Uniformity of Nature has been expressed in various forms of language, *e.g.*, 'Nature Various forms of expressing

the Law of the Uniformity of Nature.

is uniform;' 'In Nature, there are parallel cases;' 'The future will resemble the past;' 'Nature repeats itself'; 'The absent is like the present;' 'The Universe is governed by laws;' 'There are laws of Nature;' 'The same causes will produce the same effects;' and so on. These various expressions mean that **Nature behaves in the same way under similar circumstances.** If the same circumstances occur, the same events will follow. If Water quenched our thirst, or Fire burnt us in the past, under certain circumstances, Water will quench our thirst, and Fire will burn us, in future, under similar circumstances. Thus *negatively speaking, the law implies that there is no such thing as whim or caprice in Nature.* Nature cannot act irregularly or capriciously.

Under similar circumstances Nature will behave in the same way.

At first sight Nature does not appear to be uniform

At first sight, it may appear that this principle does not always hold good—that Nature is not always uniform. As **Mill** says: "Nobody believes that the succession of rain and fine weather will be the same in every future year as in the present. Nobody expects to have the same dreams repeated every night .. . .The course of Nature, in truth, is not only uniform, it is also infinitely various" As **Carveth Read** puts it · "In many ways Nature seems not to be uniform there is great variety in the sizes, shapes, colours and all other properties of things . ... the wind and the weather are proverbially uncertain, the course of trade or politics, is full of surprises". Sometimes in Nature, there are such unusual phenomena as earthquake, cyclone, eclipse, etc. How can we then say that the course of Nature is uniform?

It is true that in Nature, various kinds of phenomena occur but

all these phenomena depend for

The answer to this question is simple enough. The principle of the Uniformity of Nature does not

mean that there is no variety in Nature, that the course of Nature will be exactly the same as it had been in the past. On the other hand, it recognises that in Nature various kinds of phenomena occur. It implies, however, that all these various phenomena are subject to definite laws. Every one of them depends for its existence on certain conditions, and when the conditions are repeated, it occurs again. If the conditions which in the past produced an earthquake, a cyclone, or an eclipse, be repeated, it will occur again.

their occurrence on certain conditions and if those conditions occur the phenomena will occur.

From the above it follows that there is not one uniformity or law governing the whole of Nature but that corresponding to the different departments of Nature, there are different uniformities or laws. As **Bain** puts it: "The course of the world is not a Uniformity, but *Uniformities*". Thus in the department of Physics, there is the law of Gravitation, which holds good of all physical phenomena; in the department of Chemistry, there is the law of Definite Proportions, according to which elementary substances combine with one another in certain fixed proportions; and so on. Corresponding to different departments of Nature, there are different sciences which carry on their investigations in their respective spheres. In each of these spheres, there are definite laws or uniformities.

Consequently, corresponding to the various departments of Nature there are laws. There is not one Uniformity or Law governing the whole world, but there are various uniformities or laws governing the various departments of Nature.

It may be pointed out that though it is true that there are various departments in Nature and there are uniformities or laws governing these different departments, yet *these different laws are but parts of one whole*. Nature is not a disorganised jumble of parts but the parts are organically related to the whole. All its different parts are parts of *one* system.

These various Uniformities or Laws are not distinct but are parts of one system hence we

speak of the Unity of Nature.

Hence we can speak not only of the Uniformities of Nature, but also of the *Uniformity* of Nature. It is better, however, to use the expression, **"Unity of Nature"**, to convey this meaning. By *Unity of Nature*, we do not, to use the words of **Welton**, "mean that the Universe is an unchanging identity, but that it is a system which remains identical with itself amidst the unceasing changes of relations between its parts". Thus, Nature is a unity in variety, its various parts being parts of one whole. It is not a chaos but a cosmos.

The Law of the Uniformity of Nature must be assumed to be true in order that we may arrive at a general proposition in Induction.

The Law of the Uniformity of Nature is a postulate or formal ground of Induction. By this is meant that it forms the very basis of all inductive generalisations. **Mill** says that this is an assumption in every case of Induction. We cannot pass from the known to the unknown, from the observed to the unobserved, from the particular to the general, from the present to the past and the future, unless we *take for granted* that Nature will behave in the same way under similar circumstances. The same idea is expressed by Mill when he says that *the Uniformity of Nature is the guarantee, the ultimate major premise of all induction.* Every Induction can be thrown into a syllogism, with a major premise, which is a special form of the Uniformity of Nature, and if we have a series of syllogisms, ultimately we shall arrive at a point, where the principle of the Uniformity of Nature itself will form the major premise. (See Chapter I, Section 9 III.)

Note 1. Two meanings of "Uniformity".

Mellone makes a distinction between the two meanings of the Uniformity of Nature *viz.*, (1) the Uniformity of

Causation, and (ii) the maintenance of the present order of things in nature. **Coffey** characterises the first meaning as the *hypothetical* form, and the second meaning as the *categorical* form of the statement of the principle of Uniformity. The first form is *If the same cause occurs, it will have the same effect.* It is not asserted that the same cause will as a matter of fact occur; all that is said is that *if* it occurs, it will have the same effect. According to COFFEY and MELLONE, this is the correct formulation of the principle of Uniformity. The second form is *The course of nature will be the same in future as it had been in the past.* This form of statement is defective because our belief in the permanence of the present order of Nature is based on experience, which can never furnish certainty. There may therefore be deviations or exceptions. No doubt there is a strong presumption that the sun will rise to-morrow, but we have no grounds of affirming that the sun must rise. The hypothetical form, however, has no exception. When **Mill** expresses the principle of Uniformity by saying that "the unknown will be like the known", he is not formulating the scientific principle of Uniformity as given in the first statement but only the second form.

Note 2. The Paradox of Induction.

The Law of the Uniformity of Nature has been described by Logicians as an axiom or postulate or a formal ground of Induction. Mill calls it a "fundamental principle, or general axiom, of Induction" and "an assumption implied in every case of Induction". All these descriptions imply that the truth of the principle of Uniformity cannot be proved but that it must be presupposed or taken for granted before any Induction is possible.

Mill regards Uniformity as an "assumption" as well as an "instance" of Induction. Hence the Paradox.

Inconsistently enough, Mill also holds that the principle of Uniformity is "itself an instance of Induction," that it is "itself founded on prior generalisations". Mill maintains that the principle of the Uniformity of Nature is the result of Induc-

tion by Simple Enumeration, or in other words, it is based on uncontradicted experience. Experience gives us instances of "particular uniformities" and from these, we conclude "general uniformity," because no exception has been found to exist, and if any exception had existed, it would have come to our notice. In this way, the general principle of the Uniformity of Nature is established, and when established, it forms the foundation of all Inductions. We are thus reduced to the position that **"the ground of Induction is itself an induction."** This is known as the **"Paradox of Induction"**.

Criticism.

Criticism. (a) Mill's theory involves the fallacy of petitio principii

(a) It is clear that Mill's argument on this point is a *petitio principii.* He simply begs the question He assumes the very thing he wants to prove He says that the principle of Uniformity is "an assumption implied in every case of Induction"—that it is "the ultimate major premise of all inductive generalisations" and yet it is the result of Induction *How can it be an "assumption" and at the same time, a "conclusion"* of Induction? Induction per Simple Enumeration also relies on the principle of Uniformity, unless there is an assumption of Uniformity, we cannot in any case pass from the particular to the general.

(b) According to this view, it would follow that probability is the ground of certainty which is absurd.

(b) Another obvious difficulty in the theory of Mill is that according to him, the conclusions of Induction per Simple Enumeration are merely probable while those of Scientific Induction are certain. If the principle of the Uniformity of Nature be the result of an Induction by Simple Enumeration, it can only be probable, but it forms the basis of all Inductions, including Scientific Induction, which according to him, gives certainty. *But how can Probability be the basis of Certainty?*

Hence it follows that the principle

(c) These contradictions in the theory of Mill are the result of his empiricist philosophy. According to Empiricism, *all knowledge comes from experience* and

hence, the knowledge of the Uniformity of Nature cannot be an exception—it must also be derived from experience. The fact is that Empiricism fails to give a proper account of the origin of what are called fundamental principles, such as the principle of Uniformity is These fundamental principles cannot be proved but they form the foundations of proof They are assumed to be true and are thus called, "postulates". The Uniformity of Nature is such an assumption of Induction. Without this assumption, Induction is not possible. It is the ground of Induction and not the result of Induction

Uniformity is the ground of Induction.

Note 3. Fundamental kinds of Uniformities.

The fundamental kinds of Uniformities, as enumerated by **Carveth Read,** are as follows:—

Carveth Read.

(1) The Principles of Contradiction and Excluded Middle.

(2) Certain Axioms of Mediate Evidence, *e.g.*, the *Dictum de omni et nullo.*

(3) The Uniformities of Time and Space—that all times and spaces can be definitely measured.

(4) The Persistence of Matter and Energy, *i.e.*, the law that in all changes in the Universe, the quantities of Matter and Energy remain the same

(5) The Law of Causation.

(6) Certain Uniformities of Co-existence.

According to **Mill,** the uniformitie or laws of Nature fall under *two* main heads, *viz.*, Uniformities of *Co-existence* and Uniformities of *Sequence or Succession,* otherwise known as Causation. Induction is more concerned with Causation than with Co-existence.

Mill.

According to **Bain,** the general Uniformity of Nature may be distributed under *three* branches, *viz.*, (1) Co-existence; (2) Sequence, and (3) Equality and Inequality (Number and Quantity) Under *Co-existence* are included Order in Place and co-inhering attributes, Under *Sequence or Succession,* are included Order in Time and Causation, the third kind of Uniformity, *viz.*, *Equality and Inequality,* is the basis of Mathematics, the science of Quantity and

Bain.

Number Induction has to deal with all these three kinds of Uniformities, but in the actual working, we find Induction is almost entirely absorbed with the second head, viz., Causation.

Sec. 3. The Law of Causation.

Every event has a cause.

The Law of Causation states—"Every event has a cause"; "Whatever happens, has a cause"; or as **Mill** puts it: "Every phenomenon which has a beginning must have a cause" **Bain** states it thus: "*Every event that happens is definitely . ..connected with some prior event, which happening, it happens; and which failing, it fails*". The kindling of a fire follows regularly on the prior events of making a heap of combustibles and applying a light.

Nothing can come out of nothing.

Negatively speaking, the Law of Causation implies that there is no such thing as beginning out of nothing, or to use the words of Bain: "*the Law denies pure spontaneity of commencement.*" *Ex nihilo nihil fit*, which means, Out of nothing, nothing comes. "No change arises out of vacuity or stillness; there must be some prior event, change or movement, as a *sine qua non* (indispensable condition) of the occurrence of any new event. A fire never bursts out without some commencing circumstance, in the shape of movement, change, or activity". (Bain, Part II, p 16.)

Certain Canons of Elimination follow from the Law of Causation Whether a particular phenomenon is the cause or not depends on

The Law of Causation is a formal ground of Induction, *i.e.*, it guarantees the formal truth of inductive generalisations. There are certain principles, known as *Canons of Elimination*, which follow deductively from the Law of Causation, and these Canons form the foundations of our enquiries into the cause of a phenomenon. In order to determine

whether a particular event is the real cause of another event, we have to examine whether it conforms to the Canons of Elimination. Hence the formal truth of Induction depends on the observance of the Canons, and as these Canons are deduced from the Law of Causation, we conclude that the Law of Causation is a formal ground of Induction. whether it conforms to those Canons Hence the Law of Causation is a formal ground of Induction.

Sec. 4. Relation of Law of Causation to Law of the Uniformity of Nature.

According to certain Logicians, *e g.*, **Mill, Bain, Venn**, etc., the Law of Causation is a special form of the Law of the Uniformity of Nature. We have seen that Bain recognises three kinds of Uniformities, *viz*, Uniformities of Co-existence, Uniformities of Succession and Uniformities of Equality or Inequality. According to him, the Law of Causation is a special form of the Uniformity of Succession According to this view, the Law of Causation not only implies that every event has a cause, but also, that the same cause always produces the same effect According to some logicians, Causation is a special kind of Uniformity

According to other writers, *e.g*, **Sigwart, Bosanquet, Welton**, however, the Law of Causation and the Law of the Uniformity of Nature are distinct principles. According to them, the Law of Causation simply states that every event has a cause, and in order that we may go farther and say that the same cause always produces the same effect, we must take the help of the Law of the Uniformity of Nature. With the help of the Law of Causation, we can only discover and prove a causal connection between two events, of which the prior one is the cause and the posterior one is the effect But in order that on an According to certain other logicians, Causation and Uniformity of Nature are distinct laws and they together constitute the formal ground of Induction

observation of certain particulars, we can arrive at a general proposition, we must further believe that Nature is uniform.

Uniformity is the formal ground of all Inductions; Causation is the ground of Scientific Induction

It should be noted that the Law of the Uniformity of Nature is the formal ground of all kinds of inductions, Scientific and Unscientific, because in both there is generalisation, and generalisation is impossible unless we believe that Nature is uniform; whereas, the Law of Causation is the ground of Scientific Induction only, inasmuch as it is only in this form of Induction, that the generalisation depends on the discovery and proof of a causal connection Hence, we conclude that the Law of the Uniformity of Nature and the Law of Causation, taken together, constitute the formal grounds of Scientific Induction.

Sec. 5. Origin or Ground of Belief in the Uniformity of Nature.

Theories as to the origin of our belief in the Uniformity of Nature.

The question here is—what is the origin of our belief in the Uniformity of Nature? What is the ground or evidence on which the Law of Uniformity is believed to be true? How do we know that Nature is uniform in its behaviour? There are mainly *three theories* regarding the origin of our belief in the Uniformity of Nature:

1. The a priori or Intuitionist theory—Reid, Hamilton, etc.

The Intuitionist theory according to which the belief is an innate idea.

According to the *a priori* theory, *the belief in the Uniformity of Nature is an innate idea.* This is *a priori, i.e.,* prior to all experience, and *intuitive, i.e.,* we have an inborn faculty, called Intuition, by means of which we immediately perceive the Uniformity of Nature, as indeed all other axioms. As it is intuitive, we cannot help believing in its truth. This view is held by **Reid, Hamilton** and others

This theory is dogmatic, inasmuch as it does not give any reasons for supposing that the principle is intuitive. Besides, if the principle be intuitive, it can be expected that all men should possess a knowledge of it, but as Mill points out, the general maxim that the course of Nature is uniform "has scarcely entered into the minds of any, but philosophers". It is certainly not true that all persons, children, idiots, etc., possess a knowledge of the general law of the Uniformity of Nature.

2. The a posteriori or Empirical theory—Hume, Mill, etc.

The Empirical theory according to which the belief is founded on experience.

According to the empirical theory, *the belief in the Uniformity of Nature is founded on experience.* It is *a posteriori, i.e.,* posterior to experience and not prior to experience.

According to Mill, the Principle of Uniformity is at once the ground and the result of Induction.

According to **Mill**, the principle of the Uniformity of Nature, is itself "founded on prior generalisations. *The law of the Uniformity of Nature is a conclusion of an Induction per Simple Enumeration,* from a large number of Inductions" "Thus the ground of Induction is itself an Induction" This is known as *the Paradox of Induction* (See p. 73)

Paradox of Induction.

The Law of the Uniformity of Nature, to quote the words of Mill, "is itself an instance, of induction, and by no means one of the earliest which, any of us, or which mankind in general, can have made We arrive at this universal law by generalisations from many laws of inferior generality.... .... As however, all rigorous processes of Induction presuppose the general Uniformity, our knowledge of particular Uniformities from which it was first inferred was not, of course derived from rigorous induction, but from the loose and uncertain mode of Induction per Simple Enumeration". Thus, observing, so far as our experience goes, that men are mortal, we conclude—All men are mortal We conclude that Nature is uniform in this respect. Again, another Induction by Simple Enumeration will prove that Nature is uniform in another respect, and so on. As fresh instances of Uniformity, thus proved by Induction per Simple Enumeration, are added to our

list, we begin to suspect that Nature is always uniform; new cases of Induction by Simple Enumeration, being constantly made, each in its own sphere, would gradually strengthen the suspicion, and when finally age after age passes away and innumerable inductions are made, every one of which proves Uniformity in its own sphere, without a single contradictory instance, i.e. an instance, in which Nature acts capriciously and not uniformly, the inference that Nature in general, is uniform, is irresistible. In this way, according to Mill, the general principle of the Uniformity of Nature is established and when established, it forms the foundation of all inductions.

[For *Criticism*—see p. 74.]

3. The Evolutionist theory of Spencer.

According to the theory of Evolution the principle is instinctive in us though originally it is derived from experience. This only shifts the difficulty a step backwards. The problem does not belong to Logic.

The Evolutionist theory of **Spencer** is a special modification of the theory of Empiricism. According to Empiricism, all knowledge including knowledge of Uniformity comes from experience. According to the theory of Evolution, it is true that all knowledge originally comes from experience but these experiences accumulate and *"what is habit in the father becomes nature in the child."* Thus the belief in the Uniformity of Nature may have been due to experience in earlier generations, but now, this belief is an *a priori* or instinctive belief in us, and does not require any experience for its proof. It is clear that this theory only shifts the difficulty a step backwards and is only a special modification of the theory of Empiricism.

In conclusion, it may be pointed out that the question as to the origin of our belief in the Uniformity of Nature does not properly belong to Logic but to Psychology and Metaphysics. So far as Logic is concerned, we simply state that it is a fundamental principle, which must be taken for granted, in order that Inductions are possible. The principle of Uniformity cannot be proved but is the basis of all Inductive proof.

Sec. 6. Definition of Cause—Its marks or characteristics.

Mill defines the Cause of a phenomenon to be "the *antecedent, or the concurrence of antecedents, on which it is invariably and unconditionally consequent*"; *or "the sum-total of the conditions positive and negative taken together*". Definition of Cause.

Bain defines Cause as "the entire aggregate of conditions or circumstances requisite to the effect."

According to **Carveth Read, the Cause of any event is qualitatively, "the immediate, unconditional, invariable antecedent, of the effect," and quantitatively, is "equal to the effect".**

Let us attempt to explain the full implications of these definitions and ascertain the qualitative and quantitative marks or characteristics of the cause of a phenomenon :— Marks of Cause.

A. Qualitative marks of Causation.

A. Qualitative Marks :—

(1) *The Cause is relative to a given phenomenon, called the Effect.* (1) Cause and Effect are relative terms ;

Cause and Effect are relative terms. It should not be thought that in Nature, there are certain phenomena which are causes and others which are effects. On the other hand, the same phenomenon may be considered a cause in relation to its effects, and an effect in relation to its cause.

(2) *The given phenomenon is always an event in time.* (2) Causation implies that there is change in the existing state of things

An event in time means that there is a change in the existing state of things. If there be no change in the existing order of things, the problem of causation does not arise. But changes are constantly occurring and we ask—what is the cause of these changes? When, for instance, there is an earthquake, an eclipse or a cyclone, we ask: what are the causes? Similarly, we enquire into the causes of famine, war, a political revolution and so on. All this

implies that there was a previous state of things and that state of things has undergone a change

(3) Cause is an antecedent.

(3) *The Cause is an antecedent of the Effect.*

Causation implies succession in time, i.e., there is an antecedent which precedes and a consequent which follows. In point of time, the Cause precedes the Effect, *i.e.,* is antecedent to the effect, and the Effect follows the Cause, *i.e.,* is consequent to the Cause.

Some thinkers dispute the proposition that the Cause and the Effect always stand in the relation of antecedent and consequent It has been said that the term 'Cause' implies an 'Effect', and hence until the effect occurs, there can be no Cause Hence the Cause and the Effect are simultaneous events To this **Carveth Read** answers: "This is a blunder: for whilst the word "cause" implies "effect", it also implies the relative futurity of the effect; and the effect implies the relative priority of the cause." Again, sometimes it may happen that it takes a long time before we consider the cause as exhausted, *e g.*, a war, an earthquake, etc, and all the time the effect is accumulating In such cases, just as the cause is made up of several parts or factors, the effect is also made up of several parts or factors; and each part of the cause is antecedent to the corresponding part of the effect, though the whole cause may not be antecedent to the whole effect **Mellone** points out that in speaking of *antecedence* (or priority in time) as a mark of causation, we should not think that the cause and the effect are separate events The fact is that the course of nature is a continuous process, and that there is no break or pause. In this continuous process, the cause and the effect are distinct no doubt, but not marked off from each other. "Cause and effect are divided simply by a mathematical line—a line destitute of breath—which is thrown by our thought across the current of events, on the one side we have the cause, on the other effect."

(4) Cause is an invariable antecedent.

(4) *The Cause is an invariable antecedent of the Effect.*

The cause is antecedent to the effect, but every antecedent circumstance is not the cause. An ante-

cedent may be *variable* or *invariable*. A variable antecedent is that which is sometimes followed by the effect, sometimes not; while an invariable antecedent is that which is invariably or always followed by the effect. Every event has an innumerable number of antecedents which have no connection with it. The Cause, however, is to be sought for among those antecedents which are always followed by the Effect. This is what is meant by the "Uniformity of Causation"—the same cause has the same effect.

To mistake any and every antecedent as the Cause of an event is to commit the fallacy of **Post hoc, ergo propter hoc** [P. 177 & p. 312].

(5) *The Cause is the Unconditional Antecedent.* (5) Cause is the unconditional antecedent.

According to **Hume**, Causation is nothing more than invariable sequence and, therefore, the Cause is merely the invariable antecedent and the Effect is merely the invariable consequent. **Reid** pointed out that if that were so, Day would be the cause of Night and Night would be the cause of Day. **Mill**, therefore corrects the view of Hume, by saying, that the cause is the *unconditional* antecedent. The cause is an invariable antecedent, but every invariable antecedent is not the cause. The cause is something more than an invariable antecedent, *viz.*, it is also an unconditional antecedent. "It is not enough that the sequence is invariable . . ..The sequence must be unconditional also."

By an "Unconditional antecedent", Mill means that group of conditions which, without any further condition, is followed by the event in question. A "**Condition**" means a necessary part of a cause. Anything which exercises some influence on the effect is

called a Condition The cause is the sum-total of all conditions, *i e*, all those circumstances which exercise some influence on the effect This is what is meant by saying that the cause is the unconditional antecedent—an antecedent or a group of antecedents which contains in itself all the necessary conditions and which does not depend on any other condition to produce the effect To use the words of **Bain:** It is "the sole sufficing circumstance whose presence makes the effect, and whose absence arrests it"

(6) Cause is the immediate antecedent

(6) *The Cause is the Immediate Antecedent.*

The cause is the *immediate antecedent,* as distinguished from a remote antecedent This follows from the principle that the cause must be the unconditional antecedent For, if the cause has to wait for the occurrence of another antecedent, before it can produce the effect, it would depend on that antecedent and would not be unconditional Thus the cause is always the immediate antecedent of the effect. Immediacy follows from unconditionality

The term "Immediate however should not be taken too strictly for, in certain sciences where phenomena are treated of on a large scale there may be a noticeable interval of time between the Cause and the Effect

Proximate and Remote Cause

A distinction has been sought to be drawn between a Proximate Cause and a Remote Cause **A Proximate cause** is the condition which immediately precedes and gives rise to an effect, without the intervention of any further condition, **a Remote or predisposing cause** is the condition which precedes and gives rise to the proximate cause Thus suppose a gun is fired, the ball strikes a wall knocks it down and a man is crushed to death In this case the falling down of the wall is the proximate cause of the man s death while the firing of the gun is a remote cause

Thus, the *qualitative marks of the Cause are (i) antecedence, (ii) invariability, (iii) unconditionality* and *(iv) immediacy.*

B. Quantitative mark of Causation.

Quantitatively the Cause is equal to the Effect

Quantitatively, the Cause is equal to the Effect. This means that as regards quantity, the *matter* and the *energy* in the Cause are equal to those in the Effect This characteristic follows from the Laws of the Conservation of Matter and of Energy.

According to the *Law of the Conservation of Matter,* the total quantity of matter in the world is constant—it can neither increase nor decrease, though it may change in form Thus, when a certain quantity of Oxygen is combined with a certain quantity of Hydrogen to form Water, the form is certainly changed but the weight of Water produced is exactly equal to the weight of the substances combined to produce it Hence so far as Matter is concerned, the Effect is identical with the Cause, only the form may be different

According to the *Law of the Conservation of Energy,* again, the total quantity of Energy in the world is constant and can neither increase nor decrease, though one form of energy may be changed into another form For example, when a moving body loses its motion, it appears that the energy is lost but as a matter of fact, it is converted into another form of energy, *viz*, Heat Hence, so far as Energy is concerned, the quantity of energy in the effect is exactly equal to that in the cause.

Hence, it follows that the *quantitative mark of the Cause is its equality with the effect.*

Note 1. The Law of Conservation of Energy and its bearing on Causation.

The Law of the Conservation of Energy may be stated in the words of **Bain**, thus: *"Force, Energy, Moving Power or Work Power, is embodied in various forms, all mutually convertible at a definite (fixed) rate The extinction of energy in one form is accompanied by energy in another form: in the transmutation, Work is said to be done, and no force is absolutely lost".*

Energy means *the capacity for doing work* It appears in various forms *e.g*, Mechanical energy (such as the energy of a body falling from a height) Heat, Light, Sound, Electricity, Magnetism, Chemical energy, *etc*

Law of Conservation implies

The Law of the Conservation of Energy thus implies the following:

(i) Energy is constant.

(*i*) Firstly, the total amount of Energy in the universe is a constant quantity, which can neither be increased nor diminished.

(ii) Energy changes form; and then

(*ii*) Secondly, though the total amount of Energy remains constant, one form of energy can be changed into another form; for example: Suppose a body falling from a height strikes the ground and is at a standstill. The mechanical energy of the falling body disappears as such, but is transformed into another form of energy, *viz.*, Heat. Thus no energy is lost, though one form of energy is changed into another form.

(iii) Work is done.

(*iii*) Lastly, in the interchange of energies, Work is done.

Now Energy is of two kinds--*Kinetic* Energy and *Potential* Energy **Kinetic energy** is *energy possessed by Matter in motion* Whenever we find a body in motion it possesses Kinetic energy, *e g*, motions of a hammer, a locomotive engine in action, a ball falling from a height.

etc **Potential Energy,** on the other hand, is energy *possessed by Matter in position i.e.,* by bodies which are at rest Even when a body is at rest, it is the storehouse of a quantity of potential energy. The potential energy possessed by a body at rest may subsequently be manifested in the form of kinetic energy when the body moves, but even if there be no such manifestation, it possesses potential energy by virtue of its mere position. Now Potential Energy and Kinetic Energy are mutually convertible Potential Energy may be converted into Kinetic Energy, and Kinetic Energy, again, may be converted into Potential Energy. Suppose a piece of stone is lying on the ground. By virtue of its mere position, it possesses a quantity of Potential Energy. This Potential Energy is manifested, when, for instance, we accidentally strike our foot against it, with the result that it hurts. Now, suppose, it is thrown upwards and is lodged on the roof; the Kinetic Energy disappears as such and is converted into Potential Energy Thus the Potential Energy possessed by the stone, when it is resting on the roof is greater than the Potential Energy, it possessed when it was lying on the ground This increase is manifested when a slight push makes it move downwards with great force, whereas, a similar push would make it move only slightly, when it was lying on the ground. The increase of the Potential Energy of the stone resting on the roof is due to the conversion of the Kinetic Energy into Potential Energy. Hence there is really no loss of energy—only Kinetic Energy may change form, and become Potential, and Potential Energy may change form and become Kinetic.

Now what is the bearing of the Law of the Conservation of Energy on Causation?

The Law of the Conservation of Energy proves that quantitatively, the Cause and the Effect are equal to each other. From the standpoint of Conservation, Causation means that a definite amount of force or energy is transferred from the cause to the effect. The effect is nothing but the cause transformed The matter and the energy which disappear as cause reappear as effect. In course of transform-

The Law of Conservation proves that quantitatively the Cause and the Effect are equal to each other

ation, there is neither any increase nor any decrease. Hence the cause and the effect are equal to each other.

If it be supposed that the cause and the effect are not equal, there are three possible alternatives, *viz.*, firstly, the cause is *always greater* than the effect; secondly, the cause is *always less* than the effect; and lastly, the cause is *sometimes greater* and *sometimes less* than the effect. The last supposition is incorrect, because Nature is uniform and the cause cannot be *sometimes greater* and *sometimes less*. According to the first supposition, *viz.*, the cause is always greater than the effect, the total quantity of matter and energy in the universe will go on *decreasing*. According to the second supposition, *viz.*, the cause is always less than the effect, the total quantity of matter and energy in the universe will go on *increasing*. But according to the doctrine of Conservation, the total quantity of matter and energy in the universe is constant and there can neither be any increase nor decrease. Hence all the three suppositions are incorrect, and it follows that the Cause and the Effect are equal.

Note 2. Aristotle's view of Causation.

Aristotle's view is that the Cause is always a compound containing four factors, each of which, again, may be considered by itself as a cause These four causes are Material, Formal, Efficient and Final

(1) The **Material Cause** of a thing is the *material* or *substance* of which it is made. Whenever a change or effect is produced, it is produced in some substance and the effect will depend on the nature of this material or substance Therefore, the material in which changes are produced must be counted as an element in the causation

or changes For example, Marble or Stone which a sculptor uses is the material cause of a statue.

(2) The **Formal Cause** of a thing is the new *form* or *shape* which is imposed on the object produced. As we *know, every object possesses some form and is made up of* some material. Now, when an effect is produced, not only is there some material or substance but there is also some change in the form of the object. Thus a sculptor takes a block of marble and impresses on it the form of, say, Apollo or Jupiter or more modern hero.

(3) The **Efficient Cause** of a thing is the *labour, skill,* or *energy* spent in making the thing. It is the force which seems to pass from one thing to another, and to enter into a thing where it was not before Thus the strength or skill which the sculptor applies to the material in making the statue is the efficient cause of the latter Sometimes the agent (e g, the sculptor himself) is called the Efficient Cause.

(4) The **Final Cause** of a thing is the *end* or *purpose* for which the change is brought into existence and which was originally present in the form of an idea Thus the purpose for which a statue is made is to commemorate the exploits of a national hero

Formal and Material Causes are called *intrinsic,* because they enter into the very constitution of the thing itself, while Efficient and Final Causes are called *extrinsic,* because, they are, as it were, external to the thing.

Sec. 7. Cause and Condition.

Carveth Read: Conditions—Positive & Negative.

Carveth Read defines *Condition* as follows: "**'Condition' means any necessary factor of a Cause.**" According to him, Conditions are of two kinds, *viz., Positive* and *Negative.* "**A positive condition is one that cannot be omitted without frustrating the effect; a negative condition is one that cannot be introduced without frustrating the**

effect." Thus, according to Carveth Read, if the effect is to be produced, positive conditions must be present, and negative conditions must be absent. If, on the other hand, positive conditions are absent or negative conditions are present, the effect would be frustrated

Examples: — For example. Suppose a picture falls from the wall. The falling of the picture is the effect. The positive conditions are the violent slamming of the door, the weakness of the cord with which the picture was hung up, the heaviness of the picture etc. If these conditions had not been present, the picture would not have fallen; hence these are positive conditions. The negative conditions, on the other hand, would be some support other than the weak cord, the presence of some person at the time when the picture fell so that he might have caught hold of it, and so on. If these negative conditions had been present, the picture would not have fallen, and thus the effect would have been frustrated. Similarly, if a man crossing a river in a small boat is drowned when a sudden squall comes on and the boat founders, the *positive conditions of the man's death are the* smallness of the boat, suddenness of the squall, foundering of the boat etc.; while the negative conditions would be his knowledge of swimming, supply of life-saving appliances in the boat, some help forthcoming within range, and so on

Criticism It may be noted that Carveth Read's definitions of "Condition" and "Negative Condition" are contradictory to each other How can a Negative Condition which must be *absent* in order that the effect may be produced be a *"necessary factor* of the Cause"?

It should be noted here that Carveth Read's definition of "Negative Condition" is the very opposite of that of Mill **By "Negative Condition" Mill means "the absence of a preventing cause."** Thus while according to Carveth Read's definition, a Negative Condition means the preventing circumstance itself, according to Mill, a Negative Condition means the absence of the preventing circumstance. In the illustrations given above, according to Mill's definition, the *absence* of some support other than the weak cord would be a negative condition of the falling of the picture while according to Carveth Read's definition, the *presence* of such a support would be the negative condition; similarly, 'inability to swim' would be a negative condition of the man's death by drowning according to Mill, while his 'ability to swim' would be the negative condition according to Carveth Read.* — Mill's definition of 'Negative condition'.

What then is the relation between Cause and Condition? — Cause & Condition

Popularly speaking, we usually call one of the conditions as *the* Cause, and the others, mere Conditions. We arbitrarily select only one of the various conditions and dignify it with the name of Cause. Sometimes, one of the conditions which comes last and upon which the effect immediately follows is termed the Cause. Sometimes, one of the most striking and peculiar conditions is called the Cause. Sometimes again, even a mere negative condition is spoken of as the Cause *e.g.*, when we say that the — Popular view

*Carveth Read contradicts himself when he says that the negative condition of the falling of the picture was "that the picture should have *no* support but the cord". See 4th ed., p. 178.

absence of a sentinel is the cause of an army being surprised.

Scientific view.

This popular distinction between Cause and Condition is wholly unsatisfactory from the scientific point of view. As **Mill** puts it · **"The Cause is the sum total of the conditions positive and negative taken together."** The true relation between Cause and Condition is the relation between the whole and its parts. Condition is a part of the Cause and all the Conditions, positive and negative taken together, constitute the Cause.

It may be pointed out, however, that even from the scientific point of view, it is not possible to mention *all* the negative conditions Negative Conditions mean the absence of circumstances which prevent the production of the effect and it is quite clear that the number of such circumstances would be infinite and they cannot be exhaustively enumerated. Hence **Mill** says that Negative Conditions may be all summed up under one head, namely, *"the absence of preventing or counter-acting conditions."*

It may further be pointed out that even in enumerating positive conditions, we may omit to mention those which are obviously pedantic. For example, if we say that one of the positive conditions of the falling of the picture is the force of gravitation, it appears to be needlessly pedantic. Besides, it is necessary to mention only the proximate conditions and not the remote ones. We know that the whole Universe is a system of inter-related parts, so that in one sense, the smallest event may be said to be the effect of the universe as a whole. In enumerating the positive conditions constituting a Cause, however, it is only the "immediate" antecedents or conditions which need be mentioned, because the Cause is an "immediate" antecedent

Note 1. Moving power and Collocation.

From the standpoint of the Conservation of Energy, the Cause of an event may be analysed into *two* elements, *viz.*, (1) *Moving Power* and (2) *Collocation*. **Moving Power is the force which moves**

Moving Power—Force which

or incites to action, while Collocation means the position of objects or arrangement of circumstances, which is required in order that the Moving Power can produce changes. Now, since Causation, from the standpoint of the Conservation of Energy means that a certain amount of Energy is transferred from the Cause to the Effect, it is clear enough that the Moving Power is an ingredient of the Cause; but over and above the Moving Power, a certain Collocation or a suitable arrangement of circumstances is necessary. For example, if a glowing match stick is applied to a heap of combustibles, there is fire. In this case, the glowing match stick is the Moving Power, while the heap of combustibles is the Collocation; and the effect 'fire' is produced by the action of the Moving Power on the Collocation. Just as the effect 'fire' would not have been produced if the match stick had not been lighted, so again, it would not have been produced, if there had not been combustible substances. A glowing match stick thrown into water would not produce fire; nor would a quantity of water sprinkled on a heap of combustibles produce a fire. Thus, from the standpoint of the Conservation of Energy, both the Moving Power and the Collocation of circumstances are ingredients of the Cause.

incites to action, and Collocation necessary arrangement of circumstances in order that the Moving Power may act.

Scientifically speaking both are essential ingredients of the Cause.

Popularly speaking, sometimes we are apt to identify the Cause with the Moving Power alone, or with the Colloeation alone, but from the scientific standpoint, such views are unsatisfactory. Scientifically, the Cause is the sum-total of all conditions taken together including both the Moving Power and the Collocation.

though popularly, we often identify the Cause with one of them only.

Note 2. Agent and Patient.

Agent—That which acts, and Patient—That which is acted upon.

Sometimes a distinction is sought to the drawn between an Agent and a Patient. **The thing acting is said to be the Agent, and the thing acted upon is said to be the Patient.** For example, if a man is poisoned by prussic acid, the poison is considered as the "agent"; and the nervous system of the individual as the "patient". Similarly, when a glowing match stick, applied to a heap of combustibles, produces an explosion, the glowing match stick is said to be the "agent" and the heap of combustibles is said to be the "patient".

This is a distinction which is scientifically untenable The so-called "Patient" is also an agent because it is the seat of potential energy.

This distinction between the so-called Agent and the so-called Patient which is similar to the distinction between Moving Power and Collocation, is without any substance from the scientific point of view. This distinction appears to be based on the supposition that the Agent is the real source of energy and the so-called Patient is merely passive, possessing no energy whatever But this supposition is scientifically wrong. From the point of view of Conservation of Energy that which appears to be passive is the store-house of potential energy, and this potential energy influences the production of the effect as much as the so-called Agent, which represents Kinetic Energy or Energy in motion. Mill says that though, popularly, we call prussic acid the agent of a person's death, the whole of the vital and organic properties of the patient are as active as the poison, in producing the man's death. Hence **Mill** concludes: "The distinction between agent and patient is merely verbal; patients are always agents".

Sec. 8 Causation viewed under three aspects.

Causation may be viewed under *three* different aspects, *viz.*, *Popular* or practical aspect of Causation; *Scientific* or Complete view of Causation; and thirdly, Causation *viewed as Conservation of Energy*. Three aspects:

A. POPULAR VIEW OF CAUSATION.

Popularly speaking, "the Cause of an event is some one circumstance selected from the assemblage of conditions, as being practically the turning point at the moment" (Bain).

For example: a man slips his foot on a ladder, falls down and is killed. The cause of his death is said to be the slipping. This circumstance alone is popularly regarded as the Cause, because it is argued that if this circumstance had been prevented, death would not have happened. We know, however, that there are various other conditions which are necessary in order that the effect may happen, *e g.*, the height from which the man fell, the weight of the man's body, the peculiar physical constitution of man and so on. For practical purposes, however, we leave out of account all these conditions and mention the slipping—only one of the conditions—as the sole cause. Similarly, we attribute the issue of a war to the Commander-in-Chief; the success of a political movement is popularly supposed to be due to the personality of a great leader; and so on. Popularly, one of the various conditions constituting the cause is arbitrarily regarded as the whole cause; but

Scientifically, however, this view of Causation is wholly unsatisfactory. The Cause, scientifically understood, is the totality of conditions, positive and negative, taken together, and no condition, however this is unscientific.

prominent, can by itself be considered as the sole Cause.

B. SCIENTIFIC VIEW OF CAUSATION.

Scientifically, the cause is the sum total of all the conditions, positive and negative.

Scientifically, the Cause is "the invariable, unconditional and immediate antecedent"; or "the sum total of conditions, positive and negative, taken together". It is that group of antecedents which is sufficient to produce the effect without the presence of any other antecedent. As **Bain** puts it: "In scientific investigations, the cause must be regarded as the entire aggregate of conditions or circumstances requisite to the effect".

All the conditions suppressed by the ordinary man are included by the scientist in a full statement of the Cause. If some conditions be omitted, it is either because they are so obvious that no person would overlook them or that they are so remote that it is not necessary to mention them.

Thus in ascertaining the cause of the death of a man who slips from a ladder and is killed, the scientist would enumerate such positive conditions as, the weight of the man's body, the height from which he fell, the fragility of the human frame etc., and also such negative conditions as the absence of support, the want of skill, etc.

C. CAUSATION AS CONSERVATION.

Form the standpoint of conservation, the cause and the effect are equal to each other.

Causation viewed as Conservation means the transference of a definite amount of force from the Cause to the Effect.

According to the doctrine of the Conservation of Energy, the total quantity of energy in the world is constant; it can neither be increased nor diminished, though there may be change of form; and in this pro-

cess of change, Work is done. Hence the Effect is the same thing as the Cause in another form. Quantitatively, the Cause and the Effect are equal, and the Effect is nothing but the Cause redistributed. (See Sec. 6, Note 1, of this Chapter, p. 86).

Sec. 9. Plurality of Causes.

Plurality of Causes means that the same effect can be produced by different causes at different times.

'Plurality of Causes' means that the same effect may be produced by different Causes in different cases. As **Carveth Read** puts it: "*The same event may be due at different times to different antecedents, that in fact there may be vicarious Causes.*" For example: *Death* may be caused in one case by disease, in another by violence, in a third case, by poison, or in a fourth case, by old age. Similarly, *Light* may be produced by the Sun, the Moon, the stars, by electricity, etc. *Fainting* may be due to loss of blood, fright, sudden shock, intense pain, etc. In all these cases, it appears that the same effect is produced by different causes at different times.

The expression "Plurality of Causes" was introduced by **Mill** who explains his doctrine in the following words: "It is not true, that one effect must be connected with only one cause, that each phenomenon can be produced only in one way There are often several independent modes in which the same phenomenon could have originated . Many causes may produce mechanical motion: many causes may produce same kinds of sensation many causes may produce death"

It should be noted that the doctrine of plurality of causes does not mean that a plurality of *conditions* taken together constitutes the cause. Again it should not be confounded with the doctrine of *Conjunction of Causes*, according to which several causes combine to produce one effect (See p. 100).

Criticism.

The doctrine is unsound, because, while we take a complete view of the cause, we take a partial view of the effect.

The doctrine of the Plurality of Causes is scientifically unsound, because, it is based on a *misconception of the nature of the effect produced.* It is said that the effect 'death' may be due to different causes at different times. But the effect, strictly understood, is not a single circumstance. Just as the Cause is an assemblage of antecedents, so the Effect is an assemblage of consequents Hence though the effects produced in the different cases have only one thing in common, *viz.*, death, they are not the same in other respects. For example, Death caused by disease would certainly present certain features which are entirely absent from Death caused by poison. In fact, it is with a view to determining the exact nature of the cause of death in a given case that post-mortem examination is made. Thus, if we *specialise the effect, i.e.*, if we take the whole effect into consideration, it cannot be said to be due to different causes. If the effect be given in all its detail, there will never be more than one possible cause to account for it Thus, one way of proving the unsoundness of the doctrine of Plurality of Causes is to specialise the effect.

If we take the entire effect into account, there can be only one cause

If we take a partial view of the effect we should also take a partial view of the cause, in that case also it will be found that the effect has

Another way of proving the unsoundness of the doctrine of the Plurality of Causes, is by *generalising the cause.* Advocates of the doctrine pay attention to a particular part of the effect, disregarding its accompanying circumstances, which also form a part of the total effect If we take a partial view of the effect, we should also take a partial view of the cause. This is what is meant by generalising the cause. By "generalising the cause," we mean that we do not

take into account all the conditions, constituting the different causes but only refer to some condition which is common to the causes. Thus the so-called different causes of death have one feature in common, *viz.*, they all involve failure of vital functions, and this common condition (failure of vital functions) in the set of causes may be described as the cause of the common consequent (death) in the set of effects. In this way, we may show that a given effect can have only one cause. only one cause.

Thus the doctrine of the Plurality of Causes arises because, while, taking a partial view of the effect, we take a complete view of the cause If we take a complete view of of the effect as well, *i e*, if we enumerate all the consequents constituting the effect, we find that the total effect can have only one cause Again, if we take a partial view of the cause as we take a partial view of the effect, then also, we find that a given effect can have only one cause.

Further, the doctrine of the Plurality of Causes is inconsistent with the definition of Cause as the "invariable" antecedent If the same effect can be produced by different causes at different times, it means that the effect is sometimes preceded by one cause, sometimes by another cause. If death is produced by disease in one case and by violence in another case, it means that death is sometimes preceded by disease and sometimes by violence. Hence neither disease nor violence can be said to be the invariable antecedent. The doctrine is inconsistent with the invariability of cause.

Hence *the doctrine of the Plurality of Causes is untenable from the scientific point of view.* As **Carveth Read** puts it · "If we knew the facts minutely enough, it will be found that there will be only one cause (sum of conditions) for each effect (sum of co-effects) and the order of events Doctrine is scientifically untenable but is a practical caution.

is as uniform backwards as forwards" As **Bain** says: "Plurality of Causes is more an incident of our imperfect knowledge than a fact in the nature of things". It should be noted however that in practical investigation the possibility of a plurality of causes does present difficulties, and hence the doctrine may be regarded as "a practical working caution", as **Mellone** puts it.

Sec. 10. Conjunction of Causes and Intermixture of Effects.

Ordinarily, when there are several causes, there are separate effects. For instance, when a man receives three different blows in three different parts of the body, there are three different marks of injury, each blow being responsible for one mark In this case, each cause is acting separately to produce its separate and independent effect. The causes are separate and the corresponding effects are also separate. But in Nature, phenomena are seldom so simple Hence it often happens that several causes act together, and their effects, instead of remaining separate, are blended together. **The acting together of several causes, producing a joint effect is called Conjunction of Causes; and the combining of their separate effects is called Intermixture of Effects.** Thus the Conjunction of Causes leads to the Intermixture of Effects.

Sometimes, several causes combine to produce a joint effect

'Plurality' and 'Conjunction' distinguished.

The doctrine of Conjunction of Causes should not be confused with the doctrine of Plurality of Causes. According to Plurality of Causes, several causes, *acting separately and independently*, produce the same effect on different occasions; thus a parti-

cular effect X may be due to A *or* B *or* C; while, according to Conjunction of Causes, several causes *acting jointly* produce a joint effect, which could not have been produced by any one of them acting singly; thus a particular effect X is due to A + B + C.

There are two ways in which Conjunction of Causes may take place, and corresponding to them, there are two kinds of Intermixture of Effects *viz.*, *Homogeneous* and *Heteropathic.*

1. Homogeneous Intermixture of Effects.

In Homogeneous Intermixture, the joint effect is of the same kind with the separate effects.

When two or more causes act together so that the joint effect is of the same kind with the separate effects, the combining of effects is called Homogeneous Intermixture of Effects. In this case, each of the combining causes, operating according to its law, produces its effect, and the effects of all the combining causes are intermixed into a joint effect which is exactly equal to the sum of their separate effects, and in which, therefore, the effect of each of the combining causes is traceable. This form of intermixture is called *homogeneous*, because the causes and their effects are of the same kind. This kind of Intermixture is illustrated in *Mechanics* and *Physics.*

Examples. If there are two 50 candle-power electric lights in a room, the joint effect would be 100 c.p light If a man is carrying a weight of 20 lbs and another weight of 20 lbs. is added, the effect would be that he would carry a weight of 40 lbs. If two locomotive engines, of say, 20 h.p. each, are pulling a railway train in the same direction, the joint speed will be double the separate speed of each engine. If 5 lbs. of water be poured on 1 lb. of sand,

the joint weight will be the sum of their separate weights.

2. Heteropathic Intermixture of Effects.

In Heteropathic Intermixture, the joint effect is different from the separate effects.

When two or more causes act together so that the joint effect is different in kind from the separate effects, the combining of effects is called Heteropathic Intermixture of Effects In this case, the separate effects of the causes disappear as such, and a totally new effect is produced by their combination. This kind of Intermixture is exemplified in *chemical* and *organic* changes

Examples: Two gases, Hydrogen and Oxygen, are mixed together in certain proportions, and an electric current is passed; the joint effect is Water When Water is produced by such combination, no trace of the separate properties of the two gases can be found in the effect; on the other hand, Water presents entirely different attributes. Similarly, when a man takes certain kinds of food, digests and assimilates them, they become converted into blood, bone, muscle, etc , and the effect is entirely of a different kind

N B. We have used the expression "Conjunction of Causes" to signify the acting together of several causes, producing a joint effect, whether the intermixture of effects is homogeneous or heteropathic Some Logicians use the expression **"Composition of Causes"** to signify the same meaning **Mill,** however, employs the expression "Composition of Causes" in a restricted sense to mean only that kind of combining of causes which results in homogeneous intermixture of effects

Note 1. Tendency.

In Homogeneous Intermixture of Effects, the joint effect of two or more forces is the sum of their separate effects.

This is quite clear when two forces are acting in the same direction. But supposing two equal forces are acting in opposite directions, then the body on which these two forces are acting will be at rest, as if one of these forces had pulled it to a certain distance in one direction, and then the other force had pulled it back to its old position Thus though apparently the body is at rest as it was before and no effect is perceptible, yet as a matter of fact, the two forces are producing their effects, though they counteract each other Now *a counteracted force is said to exist in Tendency* Thus, **a Tendency means a cause which will produce an effect unless there are opposite causes which counteract it.** Thus as **Bain** says: "There is a tendency in all bodies to descend to the ground, in water to find its own level, in the moon to move towards the earth and towards the sun There is a tendency in human beings to seek their own interest; in despotic sovereigns to abuse their power The tendencies are not annihilated when they fail to be realised, they are only counteracted by some opposing tendencies"

Note 2. Progressive Effects.

Under Homogeneous Intermixture of Effects, Mill includes what are called Progressive Effects **A Progressive Effect is a complex effect produced by the accumulated influence of a permanent cause.** A Cause may be temporary or permanent A Cause is temporary, when it disappears after, producing its effect, on the other hand, a Cause is permanent when it produces the effect every moment Thus when we have a permanent cause, it really means several similar causes working successively, *e g*, the gravitation of the earth, the heat of the sun, etc The accumulated effect of a permanent cause is called a Progressive Effect

A Permanent Cause may operate in two ways to produce a progressive effect *Firstly,* when the permanent cause is invariable, it goes on producing more and more of the effect, *i e*, a progressive series of effects, *e g*, the attraction of the earth causing unsupported bodies fall towards it with increased velocity, sixteen feet in the first second, forty-eight in the second and so on *Secondly*, the permanent cause may be variable and may itself undergo a progressive change and thus make the effect doubly progressive, *e g*, the increase of heat as the sun draws nearer and nearer to the vertical position and remains longer above the horizon

Note 3. Mutuality of Cause and Effect.

Sometimes it may happen that when a causal relation is established between two facts, it is difficult to determine which of them is the Cause and which is the Effect, because they act and react on each other—each phenomenon being in turn cause and effect The two phenomena may be reciprocally cause and effect Thus A may be the cause of B and again B may be the cause of A Hydrogen and Oxygen may produce Water; and again Water may give rise to Hydrogen and Oxygen This is known as the Mutuality of Cause and Effect

This is illustrated in the causation of mental, social, and political phenomena, which are often more complex in character than physical phenomena Thus Industry produces Wealth, and Wealth again promotes Industry. Industry is the cause of wealth, which again becomes the cause of promotion of Industry in its turn Hence it cannot be said that either Industry or Wealth is absolutely the cause or the effect As a matter of fact, each in turn is the cause and the effect of the other, because of the mutual inter-action between them

In this connection, the following passage from **Sir G. C. Lewis** is well worth quoting· "Habits of Industry may produce wealth, whilst the acquisition of wealth may promote industry; again, habits of study may sharpen the understanding, and the increased acuteness of the understanding may afterwards increase the appetite for study So our excess of population may, by impoverishing the labouring classes, be the cause of their living in bad dwellings, and again, bad dwellings, by deteriorating the moral habits of the poor may stimulate population The general intelligence and good sense of the people may promote its good government, and the goodness of the government may, in its turn increase the intelligence of the people, and contribute to the formation of sound opinions among them. Drunkenness is in general the consequence of a low degree of intelligence, as may be observed both among savages and in civilized countries But, in return, a habit of drunkenness prevents the cultivation of the intellect, and strengthens the cause out of which it grows" As PLATO remarks "Education improves nature, and nature facilitates education National character, again, is both effect and cause; it reacts on the circumstances from which it arises The national peculiarities of a people, its race, physical structure, climate, territory, etc, form originally a certain character, which tends to create certain institutions, political and domestic, in harmony with the character These institutions strengthen, perpetuate, and

reproduce the character out of which they grew, and so on, in succession, each new effect becoming in its turn, a new cause. Thus a brave, energetic, restless nation, exposed to attack from neighbours, organises military institutions. these institutions promote and maintain a warlike spirit, this warlike spirit again assists the development of the military organisation, and is further promoted by territorial conquests and success in war, which may be its result . each successive effect thus adding to the cause out of which it sprang."

EXERCISE II.

1 Distinguish between Formal and Material grounds of Induction.

2 What is Uniformity of Nature? Why is it called a formal ground of Induction?

3 Explain and illustrate fully the Principle of the Uniformity of Nature What are the fundamental kinds, classes or branches of Uniformity found in Nature? Do you consider cyclones and earthquakes to be consistent with Uniformity?

4 Discuss the meaning of the principle of Uniformity of Nature and the possibility of proving it inductively Explain. 'There is not one Uniformity of Nature but many Uniformities'.

5 Distinguish *Unity* from *Uniformity* of Nature and discuss the statement that there is in nature not *a* uniformity but Uniformities How does the belief in the Uniformity of Nature originate?

6 How is the Uniformity of Nature established? Is it, strictly speaking, an Induction? If not, explain precisely its relation to Induction.

7 What is the Paradox of Induction? How would you solve it?

8 Examine the view that the ground of Induction is itself an Induction

9 What is the presupposition of Induction? Mention the different ways in which it has been formulated Which of them do you think to be the most adequate and why?

10 In what sense is the Uniformity of Nature a presupposition of inductive reasoning? State clearly what is meant by the Law of Uniformity

11 What is the ultimate principle upon which inductive reasoning is based?

12 Give the precise and full significance of the principle of Uniformity of Nature Is not this principle itself an induction?

13. Explain the principle of Uniformity of Nature Is the principle of Uniformity an induction *from experience*?

14 Explain and examine the view that the principle of the Uniformity of Nature is the ultimate major premise of every induction expressed syllogistically

15 "Belief in uniformity is based on induction from uninterrupted experience" Discuss

16 "The Uniformity of Nature can be neither defined nor proved' Discuss What are the grounds for saying that the future will resemble the past?

17 What is the law of Causation? How may the law be best expressed? Why is it a formal ground of Induction? What are the different aspects under which Causation may be viewed? Give a concrete example of each

18 State the law of Causation indicating the distinctive marks of the causal relation Explain and illustrate the distinction between cause and conditions

19 Explain the principle of Conservation of Energy How is it related to the Law of Causation?

20 If a workman carrying a bundle falls from a ladder and is killed, what do you consider to be the cause and the conditions of his death and why? A distinction may be made between *cause* from the *scientific* and *cause* from the merely *practical* point of view, in the above case what may be regarded as cause from the merely practical point of view?

21 What is meant by the Cause of an event? Explain the difference between the *cause* and the *conditions* of an event and distinguish between Proximate and Remote Cause Illustrate your meaning by examples

22 How would you define *cause*? Is the relation of logical dependence identical with that of causation?

23 Why is it said that the principle of causation is the formal ground of Induction?

A man is crossing the river in a small boat: a sudden squall of wind comes on; the boat founders and the man is drowned, what do you consider to be the cause and the conditions of his death? [P. 90]

24 What is the relation between the *cause* and the *condition* of an event? Illustrate your answer with reference to the case of a parachutist who, being unable to make a successful descent, falls and dies.

25 Why is it that one should not regard night as the cause not even as a universal condition of day?

26 What are the marks of the cause of an event when it is capable of being exactly ascertained? Explain and illustrate them.

27 A baloonist unable to make a successful parachute descent falls headlong and dies Determine clearly the cause and conditions of his death

28 In a locality there has been a sudden outbreak of crimes, how would you proceed to investigate into the cause of the outbreak?

29 Explain the conception of cause as a *group of antecedents necessary* to and *sufficient* for the effect What is meant by *negative* condition of an event?

30 "The Cause is the invariable and unconditional antecedent' 'The Cause is the sum total of the conditions, positive and negative, taken together' Explain with concrete examples the two statements and determine the relation between causes and conditions.

31 "Not sequence but continuity is the essential aspect of the causal relation" Discuss [P 82]

32 What, in your opinion, is the relation between the Principle of the Uniformity of Nature and the Law of Causation? Are these principles derived from experience?

33 A man goes out into the open air where a cool breeze is blowing and gets a cold What is the cause of his getting a cold (*a*) from the practical point of view, (*b*) from the scientific point of view?

34 What are the different aspects under which causation may be viewed and which of them is the most satisfactory?

35 If it be true that the same cause always produces the same effect does it follow that the same effect is always produced by the same cause? Give reason for your answer and support it by illustrations

36 What do you understand by the 'Plurality of Causes' and the 'Mutuality of Cause and Effect'? Illustrate your answer by examples

37 Explain and illustrate the different modes in which two or more causes combine to produce a single effect.

38 Analyse the scientific conception of Cause, and show how far such a conception is consistent with the so-called doctrine of 'plurality of causes'

39 Explain what is meant by Plurality of Causes, and the method by which the difficulty can be overcome

40 "Science does not recognise any plurality of causes" Do you agree?

41 Explain the distinction between Plurality of Causes and Composition of Causes

42 What is meant by Composition of Causes? In what sciences and in what professions is reasoning of this kind most essential?

43 Explain and illustrate:,

(a) Composition of Causes and Intermixture of Effects,

(b) Scientific and Popular conceptions of Causality.

44 "A cause is an effect concealed, an effect is a cause revealed" Examine this critically

45 What is meant by the term 'Cause' in Scientific Induction? Discuss the view that one and the same effect may proceed from a number of alternative causes

46 How is it that the same cause always produces the same effect, whereas the same effect may be produced in different instances by different means?

47 In what sense may it be affirmed and in what sense may it be denied that "a phenomenon can have only one cause"?

48 Must the same effect be due to the same cause?

49 What is a cause? Can there be a plurality of causes? Give examples to illustrate your answer

50 Is causation an aspect of the Uniformity of Nature? (See p 77) Consider in this connection whether plurality of causes vitiates the law of the Uniformity of Nature (p 99)

51 Write short notes on (a) Collocation of Conditions; (b) Conversation of Energy

52 What exactly is meant by 'Uniformity of Nature'? Is the Principle of the Uniformity of Nature itself an induction? If not, what guarantees its acceptance?

53 What do you understand by 'A is the *cause* of B'? Distinguish between (i) Cause as the sum of conditions, (ii) Composition of Causes, and (iii) Plurality of Causes

CHAPTER III.

MATERIAL GROUNDS OF INDUCTION—OBSERVATION AND EXPERIMENT—THEIR USES.

Sec. 1. Material Grounds of Induction.

Observa and Exp ment su the dat premise Inducti

In deductive reasoning, we are concerned only with formal truth and not with material truth. In Deduction, the premises are taken for granted and accepted as true without question and without any investigation. In inductive reasoning, on the other hand, we are concerned not merely with formal truth but also with material truth. The formal truth of an inductive reasoning is guaranteed by the principles of the Uniformity of Nature and of Causation Now *the material truth of an inductive reasoning is assured by Observation and Experiment.* As **Carveth Read** says: **"Observations and Experiments are the material grounds of Induction."** Induction establishes general propositions on an examination of particular instances, and these particular instances, which constitute the materials of Induction are supplied by Observation and Experiment. Thus when by Induction, we arrive at the conclusion "All men are mortal", instances of death of parti-

cular persons from which the general proposition is established are supplied by Observation. Similarly, in certain sciences, Experiment supplies the materials. The chemist, for example, takes a certain quantity of two gases, Hydrogen and Oxygen, and by using an electric current, finds that these gases combine and produce Water. From this the general proposition—In all cases, Water is composed of Hydrogen and Oxygen—is established by Induction. Thus Observation and Experiment supply the *data* or premises of inductive generalisations Let us now deal with them at some length.

Sec. 2. Observation.

Observation literally means "keeping something before the mind" and should be distinguished from careless perception.

The term 'Observation' is derived from *ob*, before, and *servare*, to keep, and thus, it literally means *"keeping something before the mind."* The derivation of the term throws light on its true meaning. Keeping an object before the mind implies much more than merely perceiving things in a careless and casual manner Hence Observation should be distinguished from casual and careless perception of the man in the street.

Observation is regulated perception.

Perception of external objects means knowledge of them, as obtained by the exercise of our various organs of sense, such as the eye, the ear, etc. When we see the Sun, we are said to perceive it; similarly, we hear the sound of thunder and thus perceive it; and so on In this way, during the day, we perceive various things in a casual and listless way. Observation involves perception, but it should be distinguished from perception without a purpose. In fact,

Observation is regulated perception. Before we undertake Observation, we have a definite object in view and we direct our perception accordingly. Hence in Observation, as distinguished from ordinary perception, we withdraw our attention from what is not relevant to our purpose, and concentrate our attention on what is connected with the object in view For example, if we want to ascertain the cause of malarial fever, we observe those circumstances which are associated with this disease, neglecting all other circumstances which appear to have no connection with it. Hence it has been said that *Observation is necessarily selective* We select those which concern us, while those which are irrelevant are rejected Thus **Observation is regulated perception of facts and circumstances with definite purpose in view.** Observation is selective

It may be pointed out that we may not only observe objects of external nature but also states of our mind Observation of mental states is called *Introspection* Thus we may observe emotions of anger, fear, love, jealousy, etc., in ourselves The science of Psychology is interested in observations of this kind Observation of mental states is called Introspection.

Observation should not be confused with *unconscious inference.* We should always distinguish clearly between facts which we really observe and what we infer from the facts observed. As **Jevons** says · "So long as we only record and describe what our senses have actually witnessed, we cannot commit an error; but the moment we presume or infer anything we are liable to mistake". Many facts which we ordinarily speak of as facts of observation, contain an element of unconscious inference and we appear to think that our senses deceive us. As a matter of fact, however, there is no deception on the Observation and unconscious inference.

part of the senses, but the error arises from hasty and unconscious inference. For example, in dim light, we think we observe a snake, while it is only a piece of rope. The fact is we do not observe a snake but *something like a snake,* something which resembles a snake in some characteristics and from what is observed, we infer, perhaps because of the excited imagination of the moment, that what looks like a snake from a distance in dim light will possess its other characteristics. Imagination fills in what is lacking, and we jump to the conclusion that it is a snake. We think we *see* what we only *imagine.* Similarly, a man may say he observed his brother from a distance in a crowd but what he really saw was some one who resembled his brother in some respects only. From this partial resemblance, he unhesitatingly judged that that person was his brother. Thus what is erroneous is not Observation, but the hasty inference which is mixed up with Observation proper. This tendency to confuse Observation with hasty inference leads to a fallacy of Observation called *Mal-observation* (See Sec. 4).

Note. Observation and Scientific instruments.

Scientific Instruments extend the natural powers of our organs of sense;

The organs of sense such as the eye the ear, etc., are highly defective as instruments of Observation Their natural powers ar estremely limited in scope For example, they cannot detect minute changes and differences of size, temperature or pressure. An object may be too small or too distant to be seen by the naked eye A sound may be too low to be heard by the unaided ear. Hence if we are confined to our unaided senses as means of Observation, the area of knowledge would be extremely small Besides, there are certain natural phenomena *e.g.*, electricity, which cannot be directly perceived by our sense-organs. Hence *scientists have invented instruments which extend the powers of our*

sense-organs beyond their natural limits and thus enlarge the field of Observation. The microscope helps us in seeing objects too small for the naked eye, the *telescope,* in seeing heavenly bodies which are too distant, the *microphone* in hearing sounds which are too faint for the unaided ear Sir J C Bose's Invention—*the Crescograph*—records pulse-beats of plants by a magnification of ten thousand times and thus helps us in realising that plant-life is akin to animal-life.

and render our observations accurate.

Besides extending the field of Observation, *scientific instruments also increase the accuracy of our observations* It is true that we can judge the weight of objects by hand but a *Balance* renders our knowledge of the weight exact and accurate. We can distinguish temperature within certain limits by the skin as greater or less but a *Thermometer* renders our knowledge in this respect accurate A *Barometer* is a better index to atmospheric conditions than our organism. A *Stethoscope* gives the doctor a more accurate knowledge of the working of the lungs than what he can obtain by his unaided ears; and so on.

Mere use of instruments does not transform simple observation into experiment.

It should be noted that **the mere use of Scientific instruments does not transform simple observation into experiment.** We are said to *observe* with a telescope There is no experiment in this case. The essential distinction between observation and experiment is that in the latter the object under investigation is itself modified, while in simple observation the object is unaffected. When we use a telescope to see a distant planet, we *observe,* because the planet does not undergo any change in the process. On the other hand, when we inject a poison into a rabbit, we make an *experiment,* because in the process the animal dies

Sec. 3. General Conditions of Observation.

Three general conditions of Observation ;—

It is not possible to lay down a set of definite rules which should be followed in every case of Observation. To observe well is an art which can only be acquired by practice and training but we can indicate certain general conditions, which the work of observation demands in those

who undertake it. **Joyce** mentions three kinds of conditions, *viz.*, intellectual, physical and moral.

(1) Intellectual condition—craving for knowledge.

Intellectually, Observation calls for the desire to know the reason of things, to have an explanation of things which occur to our experience Just as appetite for food and exercise is natural to the body, so a desire to know is natural to a healthy mind We know that Observation is something more than mere casual perception, and hence a craving for knowledge is an essential condition in Observation

(2) Physical condition—sound sense-organs supplemented by scientific instruments

Physically, it is essential that our organs of sense should be sound Thus a man who is deaf cannot distinguish the different notes of musical sounds nor can a man who is colour-blind undertake observation in which the discrimination of colours is in question. The natural powers of our sense-organs are extremely limited in scope and hence in Observation, we take the help of scientific instruments, *e.g.*, telescope, microscope, etc.

(3) Moral condition—Impartiality

The principal *moral characteristic*, necessary for scientific observation, is impartiality It is very difficult indeed to have this condition fulfilled As **Jevons** says "It is not easy to find persons who can with perfect fairness, register facts both for and against their own peculiar views" We know we undertake observation because we have some purpose in view. It may happen that we have some favourite theory and we observe those facts only which go to support that theory We may have such an unconscious bias, that facts which do not support our theory are passed over and escape observation. We shall see in Section 4 that this tendency leads to a fallacy of Observation called *Non-observation* But in order that Observation may yield correct results, we must impartially record all facts that come to our notice, instead of reading into things our preconceived notions.

Sec. 4. Fallacies of Observation.

Mill classifies fallacies of Observation into

Observation is a process of considerable difficulty and is often liable to error **Mill** points out that the fallacies of Observation are of two kinds, *viz*, Non-observation and Mal-observation. As Mill says. "A fallacy of mis-observa-

tion (or imperfect observation) may be either negative or positive; either Non-observation or Mal-observation. It is Non-observation, when all the error consists in overlooking or neglecting facts or particulars which ought to have been observed. It is Mal-observation when something is not simply unseen, but seen wrong, when the fact or phenomenon, instead of being recognised for what it is in reality, is mistaken for something else' Let us deal with these two kinds of fallacious Observation at some length. (1) Non-Observation and (2) Mal-observation.

A. NON-OBSERVATION.

Non-observation is the fallacy of overlooking something which ought to have been observed In this case, we overlook or neglect something which might have been known, and which, if known, would make a difference in our conclusion All observation is selective and in making this selection, we may overlook either (*i*) instances, or (*ii*) essential circumstances in those instances. Hence there are two forms in which the fallacy of Non-observation may occur; thus: A. In Non-observation, we overlook something which ought to have been observed;

(a) Non-observation of instances *is a fallacy in which we overlook instances, which are relevant to our enquiry.* This may occur on account of bias or preconceived opinion. We have a natural tendency to overlook instances which do not support our favourite theory and pay attention only to those instances which go to support the same. Non-observation of instances may also occur from the circumstance that some of the instances are more impressive than others; as for example, we are likely to pay greater attention to positive instances than to negative instances. Many superstitions are due to this tendency to overlook negative instances. We (a) We may overlook instances, or

take note of the few instances in which a dream bears some resemblance to succeeding events and neglecting the numerous cases in which there is no such resemblance we come to the conclusion that future events are mirrored in dreams. A priest exhorted a man, about to undertake a sea-voyage, to insure himself against shipwreck by making offerings to his deity and showed him pictures of persons who had made such offerings and had been saved. The man asked "But where are the portraits of those who perished inspite of their vows?" Similarly, we point out certain instances where dreams dreamt during the small hours of the morning were fulfilled and conclude that they always come true, without paying any heed to those other cases where they were falsified. Most of our superstitions are due to this neglect or non-observation of negative instances. In this way an accidental coincidence is mistaken for a causal connection.

(b) Essential conditions.

(b) Non-observation of Essential Circumstances: Sometimes we *overlook essential circumstances in our inductive enquiries.* In Observation, we seek to eliminate what is unessential and attend only to essential conditions, which exercise some influence on the phenomenon under investigation. This fallacy is specially common in observing complex social, political, economic and religious phenomena. Thus an increase in the number of convictions for any particular crime is taken to be a necessary proof of an increase of that particular form of crime, whereas, the increased number of convictions is perhaps due to greater vigilance on the part of the police.

It may be noted that Non-observation is a negative fallacy, because, in it, we do *not* observe

something; while, Mal-observation is a *positive* fallacy, because in it, we observe a thing *wrongly*.

B. MAL-OBSERVATION.

B. Mal-observation is wrong observation.

Mal-observation is the fallacy arising out of the wrong interpretation of sense-perception. It consists in observing a thing wrongly. Sometimes, Observations are mixed up with an element of unconscious inference. So long as we depend on pure sense-impressions, we cannot commit any mistake, but sometimes we misinterpret our perceptions with the result that we commit the fallacy of Mal-observation. Thus in the dark we mistake a rope for a snake Similarly, many people think that they have seen ghosts, when they have really seen some other object, *e g.*, a tombstone in the dim light of the moon. So again, when looking out of the window of a moving railway train, we sometimes imagine that the train is at rest, while the trees and the hills at a distance are all running in the opposite direction. So people imagine that they *see* the sun rise and set, whereas, what they really see is a set of appearances which can as much be reconciled with their view as with the opposite view. In all these cases, we see the thing, but see it wrongly, whereas, in Non-observation, the thing is overlooked altogether.

The fallacies of Observation may be illustrated by the following **Table:**

Table.

Fallacies of Observation.

- Non-observation (overlooking).
  - Non-observation of Instances
  - Non-observation of Essential circumstances.
- Mal-observation (seeing wrongly).

Sec. 5. Observation and Experiment.

It is the aim of Induction to discover the causes of events and occurrences in Nature These events however are complex and interrelated with one another and do not stand in isolation Nature does not reveal her secrets readily Her process is hidden and full of mysteries. These mysteries can be unravelled only by patient and laborious searching We find that in Nature, there are antecedents and consequents Mere antecedence however does not count for much in establishing a causal connection. We must determine which of the antecedents is the true cause. For this a careful examination of the antecedents is necessary. Now this is the function of Observation and Experiment It is by the help of Observation and Experiment that Nature's secrets are detected

Observation is (i) regulated perception.

Observation is regulated perception of events under conditions presented by Nature. Firstly, *Observation is regulated perception* and should, therefore, be distinguished from casual and careless perception of the man in the street. In our daily life, we perceive various things in a careless manner without any definite purpose, but that is not Observation. Observation is perception with a definite purpose. We undertake Observation in order to explain certain phenomena and ascertain their causes. Secondly, *in Observation, we watch events as they occur in Nature.* We notice events or changes as they occur in the ordinary course of Nature and do not produce the events ourselves. We wait for the events to happen and attend to them as they directly present themselves to us. Thirdly, *in Observation, the conditions under which the events occur are presented by Nature.* The circumstances which precede, accompany or follow the events in question depend on Nature and we are not able to control or vary them.

(ii) of natural events.

(iii) under natural conditions.

Thus the astronomer *observes* an eclipse of the sun or the moon in order to determine the causes of the phenomenon He watches an eclipse as it occurs and cannot control the attendant circumstances. Similarly, the meteorologist *observes* changes in the weather, notes the height of the barometer, the temperature of the atmosphere, the direction of the wind, etc Neither the astronomer nor the meteorologist is able to control the events which occur in the course of Nature They merely watch them with a view to determining their nature and conditions It may be pointed out here that Observation may be carried on with or without scientific instruments. The astronomer may *observe* an eclipse with the naked eye or with a telescope. Watching an eclipse with a telescope is still Observation, because the eclipse occurs in the course of Nature and under circumstances not dependent on ourselves. The instrument merely increases the limited powers of our sense-organs and makes the results more accurate. Examples:

Experiment is the artificial reproduction of events, under conditions pre-arranged and selected by ourselves, and observation of them when thus reproduced. In Experiment, events are artificially reproduced, the conditions under which they are produced are pre-arranged by ourselves, and then Observation follows. In Experiment, we do not wait for things to happen in the ordinary course of Nature. To use the language of **Bacon,** *"In Experiment, we interrogate Nature."* We put questions to Nature and cross-examine her, so that we may elicit answers, relevant to our purpose. The answers, which Nature gives, supply us with facts of the right sort, required for our investigation. In this way, we are able to ascertain necessary facts, without waiting for Nature to produce them at her will. As we ourselves produce the events, we can control the attendant circumstances.

In Experiment, the events are artificially produced and then observed.

For example: By experiment the chemist in his labora- Examples.

tory produces Water, by combining two gases, Hydrogen and Oxygen in certain definite proportions, and using an electric curernt The chemist does not wait for the combination to occur in the ordinary course of Nature but himself produces it at will in his laboratory Similarly, the physicist produces electricity in his laboratory, under known conditions, so that he can observe its properties with care, while if he had to depend on Nature, he would be confined to only such phenomena as thunder-storm, lightning and similar other ntaural occurrences.

Twofold distinction (i) In Experiment, the phenomenon is produced by ourselves; and

Thus the distinction between simple Observation and Experiment is twofold. In the *first* place, in Experiment, the phenomenon is artificially reproduced, while in simple Observation, the phenomenon is an event in the ordinary course of Nature. As **Bain says: "Observation is finding a fact and Experiment is making one."** If we watch electricity in the form of lightning, it is simple Observation; if, on the contrary, we produce electricity in the laboratory, it is Experiment. *Secondly,* it follows from the above that when we ourselves produce a phenomenon, we can control the circumstances of its happening, but when it occurs in Nature, the surrounding circumstances are beyond our control.

(ii) the conditions are under our control.

Misleading descriptions — 1 Experiment, artificial, Observation, natural.

In distinguishing Observation and Experiment from each other it is necessary that we should guard ourselves against certain misconceptions Some writers distinguish them by saying that Observation is *natural,* while Experiment is *artificial.* This description is however misleading. In Observation, though we depend on Nature for the occurrence of the event, we do not necessarily rely on our natural powers alone, but may make use of artificial scientific instruments to enlarge the scope of our sense-organs. Thus Observation is not wholly natural. Nor is

Experiment wholly artificial, because here also we have to make use of our natural powers in observing the event produced.

There are some Logicians, again, *e.g.*, **Stock**, who attempt to draw a further distinction between Observation and Experiment by saying that *'Observation is "passive experience" while Experiment is "active experience."* The basis of this distinction appears to be that while in Observation, we watch events and changes as they occur in the ordinary course of Nature without any attempt to control them, in Experiment, we ourselves prepare the special conditions under which events and changes occur. It is true that we are more active in Experiment than in Observation. It requires considerable activity to prepare the special conditions necessary for an experiment. But it is wholly wrong to suppose that even in Observation, we are absolutely passive. Observation is not mere passive reception of facts as they occur, but is guided by a definite plan or purpose. Observation is selective. We observe those facts which are relevant to our enquiry and reject other facts which are unconnected with the phenomenon under investigation. This selection and rejection require mental activity. Hence even in Observation, there is an element of activity, though in Experiment, the degree of activity is greater. 2. Observation, *passive*, Experiment *active*,

From the above it follows that there is no real opposition between Observation and Experiment. They are not different in kind. In both, we study the nature of phenomena, ascertain their causes, and explain the conditions of their happening. In fact, Observation may be described as the genus, having No real opposition.

Observation and Experiment differ only in degree.

two species, *viz*, *Simple Observation* and *Experimental Observation*. In both cases, we rely on our natural powers and study natural phenomena, in both cases we take advantage of artificial conditions; in both cases, again, there is exercise of physical and mental activity the only difference is that there is greater dependence on Nature in simple Observation than in Experiment; and there is greater activity in Experiment than in Simple Observation. Thus **Observation and Experiment do not differ in kind but only in degree.**

Sec. 6. Natural Experiments.

Natural Experiment.

A Natural experiment is the name which denotes those events, in which the processes of Nature themselves produce special conditions, under which the phenomenon in question may be observed In these cases, the phenomena to be observed are altogether beyond our control, and hence, there cannot be an experiment in the ordinary sense of the term. But we take advantage of specially favourable circumstances for our observations when for example, astronomers select special times and places for their observations. An eclipse of the moon affords us a case in point. Here the shadow cast upon the moon shows us the shape of the earth.

Sec. 7. Relative Advantages of Observation and Experiment.

Advantages of Experiment.

A. ADVANTAGES OF EXPERIMENT OVER OBSERVATION.

In all cases in which Experiment is possible, it is clearly advantageous to resort to it in preference to simple Observation, because Experiment secures complete control of conditions. The advantages of

Experiment over Observation may be summarised as follows :—

1. *Firstly, Experiment enables us to multiply our instances indefinitely.* 1. In Experiment we may multiply instances indefinitely *Repetition*

If one experiment does not enable us to observe the phenomenon under investigation satisfactorily, we may try again and again and have as many instances as we choose; but in simple Observation, we are at the mercy of Nature and must wait for a favourable opportunity. In Observation we wait for opportunities, in Experiment we create them. Suppose we want to observe a comet. As in this case, Experiment is impossible, we are limited to simple Observation. An opportunity to observe a comet may occur once or twice in a life-time. But the chemist who desires to examine the composition of Water, may make as many experiments as he chooses and satisfy himself that Water is composed of two gases, Hydrogen and Oxygen.

2. *Secondly, Experiment often enables us to isolate the phenomenon we are studying.* 2. Experiment helps us in isolating the phenomenon we are studying *Isolation.*

To *isolate* a phenomenon means to remove the phenomenon under investigation from the influence of all agents except that the influence of which we desire to observe. In Experiment, it is possible to isolate the phenomenon which we are studying, but in simple Observation, Nature presents a phenomenon in complex surroundings, and we cannot be certain that the phenomenon is not due to hidden causes which escape our attention. Suppose we want to ascertain why a candle burns in open air and is extinguished when placed inside a closed jar. On analysis, we find that Air contains several gases, principally, Oxygen

and Nitrogen. Simple Observation does not enable us to determine whether it is Oxygen or Nitrogen that makes the burning of a candle possible. By Experiment, we put a burning candle first into a jar of Nitrogen and find that the candle is extinguished; we next put a burning candle into a jar of Oxygen, and it burns all the more brightly Thus the phenomenon we are studying is isolated, and the effect of a particular agent on it is ascertained with accuracy.

3. Experiment helps us in varying the circumstances indefinitely. *Variation*

3. *Thirdly, Experiment enables us to vary the surrounding circumstances indefinitely.*

In Experiment as well as in simple Observation, we have to vary the circumstances, *i.e* , we examine different sets of circumstances under which the phenomenon under investigation occurs In simple Observation, we have to depend on the bounty of Nature for the supply of a suitable variety of instances but in Experiment, we can vary the circumstances indefinitely and thereby examine the different behaviour of the phenomenon under different conditions. Thus by Experiment we ascertain that a substance called Nitric Acid dissolves various kinds of metals such as Iron, Copper, Silver but cannot dissolve Gold.

4 Experiment enables us to examine things with coolness and care.

4. *Lastly, Experiment enables us to examine things with coolness and circumspection.*

In simple Observation, we are often taken by surprise as it were. Suppose we want to observe the nature of an earthquake; the phenomenon has practically disappeared before we are fully alive to it. In Experiment, on the other hand, we are not in a hurry, because the phenomenon to be examined is within our control Hence as **Carveth Read** puts it: "Experiment enables us to observe coolly and circum-

spectly and to be precise as to what happens, the time of its occurrence, the order of successive events, their duration, intensity and extent".

It may be noted that on account of the immense advantages possessed by Experiment, those sciences in which experiments are possible have made much greater progress than those other sciences where experiments are not possible Mechanics, Physics and Chemistry all admit of experiments and are most advanced sciences In Anatomy and Physiology, experiments are possible on a limited scale and they have not made as much progress as the physical sciences In Astronomy and Meteorology, experiments are impossible and the knowledge attained in them is correspondingly meagre.

B. ADVANTAGES OF OBSERVATION OVER EXPERIMENT.

Advantages of Observation.

Just as Experiment has certain advantages over Observation, so Observation, in its turn possesses certain advantages over Experiment These advantages generally arise out of the fact that Experiment is not possible in all cases. The advantages of Observation over Experiment are:—

1 *Firstly, Observation can be applied universally and has a wider scope than Experiment*

1 Observation has a wider scope than Experiment.

There are many kinds of phenomena which cannot be artificially reproduced, being beyond our control, *e g.*, we cannot by experiment artificially reproduce an eclipse or an earthquake. The heavenly bodies, the winds and tides, the strata of the earth are beyond our power to experiment with Agian, there are certain causes which are too dangerous to experiment with. Thus a powerful statesman may perhaps plunge his country into a war to examine its effect on social conditions, but an experiment of this kind is not to be thought of. Similarly, a physi-

cian cannot try the effect of a deadly poison on the human system, in order to ascertain whether it produces death. In such cases, we have to fall back on simple Observation and wait until the phenomenon, which we want to study, makes its appearance in the ordinary course of events. When, for instance, a man attempts to commit suicide by swallowing some poison, we may undertake Observation. We may similarly observe the effects of War when it actually takes place. Thus the range of Observation is considerably wider than that of Experiment.

2. In Observation, we can proceed both from the cause to the effect, and from the effect to the cause; but in Experiment, we can only proceed from the cause to the effect.

2. *Secondly, Observation enables us to reason from the effect to the cause, as well as from the cause to the effect but Experiment only enables us to proceed from the cause to the effect and not backwards from the effect to the cause.*

In Induction, sometimes a cause is given and we want to find out its effect. Sometimes, again, an effect is given and we want to find out its cause. In Experiment, we can take a cause and try what it will produce, but we cannot take an effect and try by what cause it was produced. Suppose by Experiment, we want to ascertain the effect of a poison on animal life. We can inject this poison into a rabbit, for instance, and find that the animal dies. From the cause, we proceed to the effect. But suppose we find a dead rabbit, and want to find out the cause of its death. We cannot, by experiment, get at the cause. In such cases, we must first conjecture a cause and then make an experiment to find out the effect of that supposed cause. Thus, here also, we are proceeding from the supposed cause to its effect. Observation, on the other hand, can proceed both backward from the effect to the cause, and forward

from the cause to the effect Thus by Observation, we can not only find out the effects of malarial fever on the human system by examining its consequents, but we can also find out its cause among its antecedents.

3. *Thirdly, Observation precedes Experiment.*

Experiments are possible only when some knowledge has already been acquired by simple Observation. Experiments, to be successful, require careful preparations beforehand, but unless by previous observations we know in a general way what we are to expect, adequate preparations are not possible. 3 Observation precedes Experiment.

EXERCISE III.

1. What do you understand by Elimination? 'Observation and Experiment are aids to elimination' Explain.

2 Define Observation and Experiment, giving examples of each; Explain why these processes require treatment in Inductive Logic What sciences depend mainly on Observation and why? What sciences depend mainly on Experiment and why?

3 Induction derives its premises from Observation and Experiment describe and exemplify these two processes, showing clearly the differences between them In what does the superiority of Experiment, as a source of premises, consist?

4 Distinguish between Observation and Experiment, and point out their importance in inductive enquiry Do they alone justify an inductive generalisation? Illustrate the fallacies which arise from their wrong use

5 Examine the relation or distinction between (a) Experiment and (b) the use of Instruments in Observation Give examples showing the utility of each

6 To what extent do (a) unintentional inference and (b) selective interest enter into the process of scientific observation? What precautions must be taken in Observation and Experiment to avoid error?

7 (a) What is meant by Scientific Observation?

(b) Illustrate the use of Observation and Experiment in finding out (i) the cause of an epidemic and (ii) the effects of a poison

8 'Scientific Observation is always selective and purposive". Discuss Explain why in scientific investigation Experiment is usually more advantageous than Observation.

9 "I see my brother" How far is this affirmation based on Observation and how far on inference?

10 Distinguish between Non-Observation and Mal-Observation, giving concrete examples of their various forms State your opinion as to which is more common in actual life

11 Can Non-observation ever be a proof of the non-existence of a thing or event? Examine the validity of the claim advanced in the following case "A man accused of theft on the evidence of two witnesses offered to produce in his defence ten witnesses who had not seen him commit the theft"

12 Point out the main sources of error in Observation and indicate how observers can best guard themselves against these

13 Give an example of the fallacy of mistaking an inference for an observed fact

14 Write explanatory note on the fallacy of mal-observation What are the fallacies of observation and how are they caused?

15 'Observation is finding a fact and Experiment is making one' Discuss the statement fully.

16 Observation and Experiment are said to be the material grounds of Induction Explain what precisely you understand by this and discuss the relative value of observation and experiment

"The distinction between experiment and observation is never absolute" Discuss

17. Explain the nature of Observation and Experiment and determine their place in scientific knowledge.

18 How does Experiment differ from Observation? In what respects is Experiment superior to Observation? Has Observation any advantages over Experiment? If so, what?

19 How far is it true that 'Observation and Experiment do not differ in *kind* but only in *degree*'

20 "A perfect experiment establishes a law" Explain this with examples and show wherein the superiority of Experiment over Observation lies.

21. What is a Fact? In what sense are facts the foundation of science? Explain in this connexion the superiority of Experiment over Observation Give concrete examples

22 "Neither observation nor experiment is possible without a hypothesis" Do you agree? Explain in this connection the respective provinces of Observation and Experiment

23 'Experiment is always preferable to Observation.' Why? Is 'regulated observation' very different from experiment?

CHAPTER IV.

HYPOTHESIS—ITS USES AND CONDITIONS.

Sec. 1. Introductory.

Induction aims at causal connection

Scientific Induction aims at the establishment of a causal connection amongst phenomena In order to be able to do so, it relies on its *formal* grounds, *viz.*, the law of the Uniformity of Nature and the Law of Causation. Scientific Induction starts with the presuppositions that Nature is uniform in its behaviour and that every event in the universe has a cause. As Scientific Induction aims at material truth, it further has its *material* grounds, *viz*, Observation and Experiment Observation and Experiment furnish the materials or premises of Induction, and these materials consist of particular facts of experience. From these particular facts, we aim at arriving at a general proposition, by establishing a causal connection But before we can discover and prove a causal connection, we must, somehow or other, suspect or suppose that there is such a connection Such suspicion or supposition which forms the starting-point of an inductive investigation leads to the formation of a Hypothesis.

Before a causal connection is established, it is *supposed* to exist Such a supposition is a hypothesis.

Sec. 2. Importance of Hypothesis in Induction.

The place of Hypothesis in the scheme of inductive enquiries has been a matter of some dispute

Bacon. among Logicians. **Bacon,** who is regarded as the Founder of Inductive Logic, condemns the process of *"anticipating Nature," i.e.,* framing hypotheses as to what the laws of Nature probably are. Bacon thinks that Observation and Elimination are sufficient for the purpose of detecting the laws of Nature. But such a view is obviously wrong, because, even Observation and Elimination, if they are to produce any good results, necessarily involve the use of hypotheses. Observation is not random perception, but perception with a definite purpose. The purpose is the explanation of some fact, and when the real explanation is yet unknown, a supposition or hypothesis, as to what the real explanation is, must take its place. Similarly, Elimination requires that accidental factors should be excluded in order that relevant facts should be ascertained. But how should such an exclusion be made, unless there is a guiding principle in the form of a hypothesis when the real cause is yet to be known. Hence, Bacon is not at all justified in disparaging hypotheses.

Newton. **Newton** appears to follow in the footsteps of Bacon in this respect, when he says, *"Hypotheses non fingo"* or I do not imagine hypotheses. Newton, however, does not condemn hypothesis in the modern sense of the term. By 'hypothesis' Newton understands rash and premature conjectures made on insufficient grounds, and these he rightly disregards.

Mill According to **Mill,** the place of Hypothesis in Induction is somewhat subsidiary, because, Induction, he thinks, is more concerned with Proof than with Discovery

Whewell **Whewell,** who holds the opposite view *viz*, that Induction is concerned with Discovery and not with Proof, lays great stress on Hypothesis It should be pointed out,

however, that whether Induction is concerned with Proof or with Discovery, the importance of Hypothesis in Inductive Logic cannot be denied. It is true that the actual framing of a hypothesis is the work of an inventive genius, and Logic cannot possibly undertake to frame rules as to how hypotheses are to be framed. But Logic will certainly investigate into the question as to what the circumstances are which are likely to suggest hypotheses, and before hypotheses are framed, what conditions should be fulfilled in order that the hypotheses in question can be accepted as the basis for scientific investigation, and lastly, after hypotheses are framed, what constitutes their proof or disproof

Hypothesis and Induction

What then is the function of Hypothesis in Induction? The word 'Induction' is ambiguous and sometimes means the *process* of establishing general propositions, and sometimes the *product* of such process *viz.*, the general proposition itself

Hypothesis is the starting-point.

If we regard Induction as a *process* of discovering and proving general propositions, we may state that *Hypothesis is the starting-point of Induction.* Before a general law is discovered and proved, we must start with a provisional supposition as to what it might be, and this provisional supposition is the Hypothesis. Even at the stage of Observation, Hypothesis is necessary to guide and control our perceptions.

Hypothesis is the first stage

If, on the other hand, we understand by 'Induction', the general proposition itself which is established as a *result* of our investigations, we may state that *Hypothesis is the first stage of Induction.* At the first stage there is the provisional assumption or

hypothesis; when the hypothesis is verified, it is raised to the status of Induction.

Sec. 3. Meaning of "Hypothesis."

Mill's definition

Mill defines Hypothesis as follows :—

"An hypothesis is any supposition which we make (either without actual evidence, or on evidence avowedly insufficient) in order to endeavour to deduce from it conclusions in accordance with facts which are known to be real; under the idea that if the conclusions to which the hypothesis leads are known truths, the hypothesis itself either must be, or at least is likely to be, true."

Hypothesis thus involves the following steps —

Three steps—Observation

(*i*) Observation presents some fact to be explained. There is an eclipse of the sun or the moon What is the explanation? Why does an apple fall to the ground? There should be some explanation for this event.

Supposition and its

(*ii*) Hypothesis or a *supposition* is made to explain the facts which call for an explanation. At this stage, the materials supplied by Observation are insufficient but in order that we can account for the facts presented, we must make some supposition

Verification.

(*iii*) The provisional supposition is made under the idea that if we deduce conclusions from the supposition, and find that the conclusions tally with facts, the hypothesis is true or is at least likely to be true, if not, the supposition is worthless and must be discarded in favour of another provisional supposition Thus Hypothesis involves *Deduction* and *Verification*

Hypothesis in every-day life

In our everyday life, we are constantly making suppositions to explain facts which come to our experience If, on returning home in the evening, we find that a glass pane of the window had been

broken we may suppose, for instance, that a stone or a similar object had been thrown against it. Acting on this supposition, we would look for the stone in the room. If it be found there, the supposition is confirmed; if no traces of a stone or any similar object can be discovered, we abandon the supposition and frame another supposition—perhaps it was due to the violent closing of the window by the wind; and so on. Similarly, if a man be attacked with cholera, we may suppose that he has probably taken impure water. Whenever we see something striking or unusual, we begin to guess out its explanation. Thus we frame hypotheses to explain phenomena.

The illustrations given above show the popular use of Hypothesis. In the strictly scientific use of the term, any and every guess or conjecture is not a Hypothesis. A supposition in order to be called a Hypothesis must conform to certain conditions. But both popular and scientific uses of the term agree in this that Hypothesis is a provisional supposition made in order to explain some fact or phenomenon. To take an example of a scientific hypothesis. Newton saw an apple fall to the ground and supposed that it was due to the attraction of the earth. This supposition was subsequently proved to be true, and the Law of Gravitation was established. Hypothesis in Science.

Hence we conclude: *"An hypothesis is an attempt at explanation: a provisional supposition made in order to explain scientifically some fact or phenomenon."* (*Coffey*, Vol. II, p. 121.) Hypothesis is a supposition for explaining phenomena.

Note. Hypothesis, Theory, Law and Fact.

The word 'FACT', however, is sometimes used to indi- highly ambiguous and each of them has been used in a The words are ambiguous.

variety of senses, particularly, because, they have passed into popular phraseology, and their strict scientific meaning has been obscured Even scientists are not consistent in their use of the words.

Three different stages in the process.

The proper use of the words 'hypothesis,' 'theory' and 'law,' appears to be to regard them as the three different stages in our progress from an unverified provisional supposition to a well-established law of Nature At the first stage, we have a provisional assumption or supposition which is called a 'HYPOTHESIS'. As it becomes more and more verified, the hypothesis becomes more dignified and should be called 'THEORY' The Theory, in turn, may work so well, and is so satisfactorily proved, that it is generally accepted and becomes the instrument of further prediction and interpretation At this stage, the theory becomes a 'LAW' It must be distinctly understood, however, that these stages are not absolutely marked off from one another. It is impossible to point to a definite stage, when a Hypothesis is elevated to the rank of a Theory, and again, when a Theory is elevated to the rank of a Law. Hence different writers have used different expressions in respect of the same doctrine· thus, some speak of the *theory* of Evolution, others of the evolutionary *hypothesis*; similarly, some speak of the *theory* of gravitation, others, of the *law* of gravitation.

"*Hypothesis*" is a provisional supposition: when verified, it becomes a "*theory*"; when well-established, it becomes a "*law*".

Ambiguity in the word: "Fact" = concrete experience.

The word 'FACT' is generally employed to signify "concrete events of experience", whether of the external world or of mind Facts of the external world are known by the evidence of our sense-organs, such as sights which we see, sounds which we hear, and so on Mental facts are known directly by the mind, such as our joys and sorrows

"*Fact*" = well-established law.

The word 'FACT' however, is sometimes used to indicate a 'law', which is so well-established that it is taken for granted in the world of commonsense and the world of science If we accept this use of the word 'fact', we may say that *scientific thinking begins with facts* (in the sense of concrete experiences) *and returns to facts* (in the sense of well-established and accepted laws). Thus, *facts* as concrete experiences, indicate a provisional supposition or *hypothesis*, a hypothesis is verified and develops into a

theory; a theory proves to be an instrument of satisfactory explanation of various phenomena and becomes a *law;* and lastly, a law becomes so well-known that it becomes a *fact*

Sec. 4. Origin of Hypothesis.

Logic does not presume to lay down rules as to how scientific hypotheses should be framed The origin of Hypotheses is not amenable to logical rules It is true that hypotheses are framed for the explanation of phenomena which occur in our experience But the actual framing of the supposition is the work of an inventive genius It is here that the sagacity, genius and originality of the scientist get their free scope It has been by a flash of genius or inspiration that great scientific theories have been discovered Many a person had seen the falling of an apple, many a person had noticed the dancing lid of a steam-kettle, but it was reserved for such genuises as Newton (1642-1727) and James Watt (1736-1819) to discover and establish the Law of Gravitation and the principle of the steam-engine But though the invention of scientific hypotheses cannot be due to an observance of a set of rules, we may consider the principal ways in which hypotheses are suggested They are *three* in number *viz*. (*i*) By *Enumerative Induction*, (*ii*) By *Conversion of General Propositions;* and (*iii*) By *Analogy*.

Hypotheses are invented by a flash of genius, but they may be suggested in three ways:—

1 Enumerative Induction.

Enumerative Induction may be *Perfect* or *Imperfect* In Perfect Induction, we examine all the particulars and arrive at a universal conclusion In Imperfect Induction, we observe that so far as our experience goes, two things always go together. Thus in both forms, we find that two attributes are associated together but we do not know whether there is any causal connection In the Method of Agreement also, we take several instances which agree in the presence of some circumstance. The Method of Agreement cannot *prove* a causal connection but it *suggests* a causal connection (P. 178.) Thus, when we find that two phenomena are constantly associated together, we suppose that there is some causal connection, and frame a hypothesis

1. *Enumerative Induction.* When two attributes are found to be associated with each other in experience, we suppose there is a causal connection

2 Conversion of General Propositions. When we have a general proposition it *suggests* that the relation between the subject and the predicate may be reciprocal.

2. Conversion of General Propositions.

As a result of growing experience, we obtain certain general propositions, *e g*, All crows are black, All men are mortal. We feel inclined to examine whether these propositions can be *simply converted*, or to express the same idea in different language, whether the universal connection is reciprocal. All crows are black, but, are all black birds, crows? All men are mortal, but are all mortals, men? In these cases, we find that no reciprocal relation exists This leads us to enquire what it is in men that makes them mortal. This suggests hypotheses and we find that men die, because, they possess life And when that is found we see that a reciprocal relation exists, and we arrive at the universal proposition, "All living beings die"; and then we can convert this *simply*, and say, 'All beings, which are subject to death' *are* living beings"

3 Analogy. When two things resemble each other in some respects we *suppose* that they resemble each other in other respects.

3. Analogy.

Analogy is a kind of inductive argument based on imperfect resemblance between two things, Analogy does not conclusively prove a causal connection but it is a most fruitful source of hypotheses Things, that are alike, suggest the same nature and consequently the same attributes When we find two things resemble each other in certain important attributes, we frame the hypothesis that they will possibly resemble each other in other respects Thus when we find that the Earth and the planet Mars resemble each other in possessing similar kind of atmosphere, land, water, etc, we suppose that the planet Mars will further resemble the Earth in being inhabited by living creatures Thus Analogy suggests hypotheses (See Chapter VI, p. 217).

Sec. 5 Forms of Hypothesis.

Three forms

Hypothesis assumes *three* different forms, according to the subject-matter about which suppositions are made, *viz.*, Hypothesis concerning the *Law* of the operation of a known agent; Hypothesis concerning an *Agent*, when the law of its operation is known; and

lastly, Hypothesis concerning a *Collocation*. Let us consider these forms separately :—

(1) Hypothesis concerning Law:

(1) Hypothesis concerning Law;

Suppose the agent is known but the law or plan, according to which it acts, is not known. We frame a hypothesis as to the way in which in the given case, the agent acts. To take an example from everyday life. we may know that some thief has committed burglary in the house but we may not know *how* he managed to do it. To take an illustration from science. The Law of Gravitation was established by a hypothesis of this kind. The agents, *viz.*, the Earth, falling bodies on the earth, the Sun, the Moon, and other planets were all known but the way in which the agents acted was not known. Hence it was supposed that their motions might be due to their attracting one another in a particular way. In this way, the Law of Gravitation came to be finally discovered.

(2) Hypothesis concerning Agent:

(2) Hypothesis concerning Agent; and

The Law may be known, *i.e.*, other objects may be known to operate in a particular way, but it may be that the particular agent which is to operate according to this known law may be unknown. In such a case, we frame a hypothesis concerning the agent. For example, we may frame a hypothesis concerning the cause of malarial fever The planet Neptune was discovered by a hypothesis of this kind. The Law of Gravitation was known and it was calculated that the planet Uranus should move in a particular orbit, because of the attractions of the then known planets. But it was observed that as a matter of fact, the planet

Uranus was deviating from its calculated path. This led to the supposition that there was some unknown agent, the influence of which caused these deviations. This unknown agent was subsequently discovered to be the planet Neptune.

(3) Hypothesis concerning Collocation:

(3) Hypothesis concerning Collocation.

Collocation means an arrangement of circumstances which makes it possible for the effect to occur. Thus when a match stick is applied to a heap of combustibles, and there is an explosion, the heap of combustibles is the collocation. Not only the agent, the match stick, but also the collocation is responsible for the effect If in a given case, the agents are known but the collocation is not known, it may be necessary to form some hypothesis concerning the latter Thus formerly, according to the Ptolemaic system (PTOLEMY—Egyptian astronomer: about 127 A.D.), the Earth was regarded as the centre of the universe, and it was supposed that the Sun, the Moon and other planets all revolved round the Earth. But COPERNICUS (Polish astronomer, 1473—1543 A.D.) framed a different hypothesis as to the collocation of the heavenly bodies and discovered that the order of the solar system was maintained, because, the Sun was the centre of that system, and all other bodies moved round the Sun.

Hypothesis of Law and Hypothesis of Cause

It may be noted that, scientifically speaking, the agent and the collocation taken together constitute the cause. Hence some Logicians mention only two forms of Hypothesis, *Hypothesis of Law* and *Hypothesis of Cause*.

go together.

It should not be supposed that in every case these forms of hypotheses are formed separately. On the

contrary, they may all be blended together in a given case. Thus in explaining the phenomenon of the transmission of light, scientists had to frame hypotheses both as to the agent, *viz.*, Ether, and the law of its operation, *viz.*, transmission of waves of a particular form.

Sec. 6. Conditions of a legitimate or valid Hypothesis.

Hypothesis is a provisional or tentative supposition. But any and every supposition is not a scientific Hypothesis. A supposition must conform to certain conditions, in order that it may be accepted as a hypothesis in science. When a supposition conforms to these conditions, it is called a **a legitimate** or **valid hypothesis**. The conditions to which a supposition should conform before it attains the rank of a legitimate hypothesis are as follows:—

A scientific hypothesis must conform to the following conditions and should thus be *legitimate* or *valid* —

(i) The Hypothesis must not be self-contradictory or absurd but should be conceivable and definite.

(i) Hypothesis should not be self-contradictory, but should be definite

The Hypothesis should not be self-contradictory but should be *conceivable, i.e*, consistent with itself. We should not assume, for instance, that a particular cause would behave differently under similar circumstances.

The Hypothesis should be definite and not vague. A hypothesis is framed to explain a certain phenomenon, but if it be vague, the phenomenon remains unexplained. For instance, it is no good saying that an earthquake is due to *some* disturbance in the

interior of the earth. A legitimate hypothesis must definitely conceive what the nature of the disturbance is.

The Hypothesis must not be absurd. If a man is missing from his home, we should not suppose that he was carried away by the angels. Similarly, we should not suppose that the Earth is being supported on the crest of a serpent, or that an eclipse of the Sun or the Moon occurs, because, a malicious demon devours the Sun or the Moon at certain intervals. It should be pointed out, however, that this condition is not of much value because, many things which appear absurd to some persons may not so appear to others. In fact, many things, which were pronounced absurd at some period of time, were subsequently found to be existing in fact. When Columbus (1451-1506) framed the hypothesis that there was another continent in existence besides those which had been known at the time, wise people shook their heads and said that the supposition was absurd; but the new continent, *viz.*, America, was discovered. Similarly, at one time it appeared absurd, that the Earth should be revolving round the Sun, or that the shape of the Earth should be round, and so on.

ii) Hypothesis should not conflict with established truths.

(ii) The Hypothesis must be free from conflict with established truths.

The Hypothesis which is framed must not contradict other established truths or laws. This condition requires that we should take into account the achievements of the past. Certain things have been established rather definitely, and any novel suggestion, which contradicts one of such well-etablished laws,

should be treated with suspicion. Knowledge is an organised system and its various parts are inter-related with one another. Hence if we make a supposition which goes counter to established laws, the chances are that such suppositions are incorrect.

This rule however must not be understood to mean that the cause supposed must always act in accordance with laws with which we are familiar. All that is necessary is that the supposition should not violate a law of which we have positive evidence. Sometimes, we are compelled to suppose a cause which acts in a manner, to which we have known no parallel. To think otherwise would be to assume that knowledge has reached a stage of finality, whereas, science is always increasing the bounds of knowledge and the cherished theories of one generation are abandoned in favour of new ones in the next generation. Hence this rule should not be interpreted literally but should be regarded merely as a rule of caution.

(iii) The Hypothesis must be based on facts and must have for its object a real cause or vera causa.

(iii) Hypothesis must be a *vera causa*.

To begin with, there is a preliminary observation of facts. We must observe facts without bias and then frame a hypothesis to explain them. Next, when we proceed to test the hypothesis, we should again observe facts impartially and without any bias Thus a Hypothesis depends on facts in its origin and also for its verification.

If the hypothesis refers to an agent or cause, it should be a *vera causa*. As **Newton** says: "Only *vera causa* are to be admitted in explanation of pheno-

mena." The term **"vera causa"** literally means a true cause It should not, however, be used merely to signify a cause which is actually known to exist, or something which is directly perceptible by the senses. If we use the expression in this restricted sense, we cannot, for instance, regard an atom or Ether as a hypothesis, because, neither of them is perceptible to the senses. Hence the expression should be understood to mean *"a cause which may reasonably be believed to be existing and whose existence, therefore, does not involve self-contradiction."* Besides, though such causes as an atom or Ether are not *directly* perceptible, they may be said to be *indirectly* perceptible, inasmuch as their effects are perceptible by the senses **Bain** calls them **"Representative Fictions'**

The real significance of this condition is that it excludes purely fanciful guesswork about causes. Superstitious people, for example, violate this rule by attempting to explain facts by witchcraft or such other agencies which are outside the scope of human experience

(iv) Hypothesis must be verifiable

(iv) Lastly, **the Hypothesis must be verifiable.**

To say that the hypothesis must be verifiable means that it must admit of proof or disproof. A hypothesis, to be legitimate, must be capable of either being proved or disproved. It must be such that we can deduce consequences from it in order to compare them with actual facts. A hypothesis from which nothing can be deduced is of no value whatever. It is a mere guess which has no significance, for it is entirely incapable of proof or disproof. Thus the most essential condition of a legitimate hypothesis is that

ould be deducible from it, so that it may gramme for further investigation.

we make an assumption that certain re due to some agency, which is wholly ng of which we have any experience, for spirit or ghost, it would be impossible ve or disprove the assumption. But suppme such an agency as Ether. Though it y perceived by the senses, it is conceived other material objects, inasmuch as it able of receiving and sending out vibraspread out in space. By virtue of these other material bodies, it is possible to quences which such a substance as Ether , and compare them with actual facts.

iters have sought to lay down other conditions are not, strictly speaking, conditions which ust fulfil, in order that it may form the basis vestigations, but they are conditions which ed if the hypothesis is to be *proved* They ich *conditions* of a legitimate hypothesis as gitimate hypothesis, after it is framed and as begun As **Carveth Read** says. "Except of verifiability, and definiteness for the sake without which a proposition does not deserve n hypothesis, it seems inadvisable to lay down gitimate hypothesis"

The important conditions are *verifiability* and *definiteness*.

Carveth Read.

oof of Hypothesis.

othesis is a provisional or tentative out any and every supposition is not a othesis. A supposition must conform to tions in order that it may become 'legitigitimate hypothesis affords a basis for estigation. Now the question is · How gitimate hypothesis? When a legitimate proved, it attains the rank of a Theory

or Law. A legitimate hypothesis should be *tested* in the following ways so that it may be ascertained whether the supposition affords a real explanation of the facts, for the explanation of which it is framed :—

1 Verification.

1. The first requisite of the proof of a hypothesis is Verification.

Verification means an appeal to actual facts. Verification of a hypothesis may be *direct* or *indirect*. Direct Verification consists in direct Observation or Experiment, while Indirect Verification consists in Deduction, and in Accumulation of consistent facts.

Direct Verification.

Verification is **direct**, when a direct appeal to the facts of experience confirms the hypothesis in question. It may be done by simple Observation or by Experiment. If *Observation* shows that the supposed cause is found to exist where it is assumed to be, the hypothesis is verified by Observation. Thus, the deviations from the calculated path of the planet Uranus were supposed to be due to the existence of a new planet, and when Observation with the help of a telescope showed that the planet Neptune was there in the expected region, the hypothesis was verified. Similarly, *Experiment* can verify a hypothesis. It was found that Oxygen obtained from the atmosphere was slightly heavier than Oxygen obtained from other sources, and scientists framed the hypothesis that in the atmosphere, Oxygen was mixed up with a certain other gas. By Experiment, it was found that if Oxygen were eliminated, there remained a residue, *viz.*, the gas, Argon. In this case, the hypothesis is verified by Experiment.

(i) by Observation or

(ii) Experiment.

Or Indirect Verification

Verification may sometimes be **indirect**. When direct Observation or Experiment cannot be applied

we *deduce consequences from the hypothesis and compare the consequences with the actual facts.* There are certain causes, for instance, which, by their very nature, cannot be perceived by the senses; such as ether, atom, etc In such cases, we deduce consequences from them, and compare them with facts. If the deduced consequences be found to agree with facts actually observed, the hypothesis is verified; if they do not agree, the hypothesis is disproved. Here Verification is indirect, because we cannot directly observe the supposed cause but we observe the consequences deduced from it. Sometimes, Indirect verification may assume another form. We cannot expect to have the same sort of rigorous verification in every department of scientific investigation. In such cases we have to remain content with *accumulating facts and evidence.* If we find that there is a large number of facts consistent with the hypothesis, and contradictory facts are absent, we may be satisfied to some extent that the hypothesis is verified.

(1) By Deduction or

(ii) Accumulation of consistent facts.

2. The hypothesis must be adequate to explain the facts and that it must be the only hypothesis to do so.

2. The Hypothesis is proved if it be adequate to explain all facts and

Verification is merely the first stage in the process of proving a hypothesis, and it is not to be supposed that Verification of a hypothesis amounts to a conclusive proof' of it. "To identify the Verification of a hypothesis with its proof is to commit the fallacy of affirming the consequent." The process of Verification may be illustrated in the form of a hypothetical-categorical syllogism thus·

If the hypothesis be true, its consequences are true
Its consequences are true
∴ The hypothesis is true.

It is clear that this involves the fallacy of affirming the consequent. Hence in proving a hypothesis conclusively, something more than Verification is necessary *viz.*, it must be shown that the hypothesis can *adequately* explain all the facts for the explanation of which it has been framed, and further that it is the *only hypothesis* to do so. This is *the Law of Parsimony*.

is the only hypothesis to do so.

Bacon. Crucial instance.

Jevons

Sometimes, we find that there are two or more rival hypotheses which appear to afford an explanation of the facts In trying to ascertain which of them affords the real explanation, we take what **Bacon** calls a crucial instance. **A Crucial instance** (*instantia crucis*) *is an instance which can only be explained by one of the contending hypotheses and not by the other.* A crucial instance may be obtained by simple Observation or by Experiment. If it be obtained by Experiment it is called an **"Experimentum Crucis" or crucial experiment.** The term "Crucial instance" is, as Bacon says, "borrowed from the *crosses* (or finger-posts) which are put up in crossways to point out the different ways". When we come to the crossing of two roads and are unable to decide which way we should take to reach our destination, the finger-post decides that conclusively and indicates to us the way we should take Similarly, when we obtain a crucial instance, it decides conclusively which of the rival hypotheses is proved Thus to use the language of **Jevons:** "A crucial instance not only *confirms* one hypothesis but *negatives* the other". Of course, if the crucial instance be obtained by Experiment or in other words, if it be an "experimentum crucis", its value as a means of

proof is greater than that of an instance obtained by Simple Observation. Examples.

As *examples of crucial instances obtained by Simple Observation,* we may take the following:

(1) Suppose there is a theft in the house and we are unable to decide whether the thief was in league with any inmate of the house or not In the course of an investigation we discover a plan of the building (showing the location of the room where valuables were usually kept) lying on the floor near the opening in the wall through which apparently the burglar effected his entrance into the room. This fact is a crucial instance—it conclusively proves the former hypothesis and disproves the latter, because the information contained in the plan could have been supplied only by an inmate.

(2) *Another Example*· There were two rival hypotheses, *viz*, the Ptolemaic theory, (according to which, the Earth is the centre of the universe, and the Sun, the Moon and other planets revolve round the Earth) and the Copernican theory, (according to which the Sun is the centre of the universe) It was found that the phenomenon of the aberration of light could be explained only by the Copernican theory and not by the Ptolemaic theory. Hence this phenomenon is a crucial instance which establishes the former theory and disproves the latter

As examples of crucial experiment (Experimentum Crucis) we may take the following instances:

(1) Suppose, there is a glass jar containing some gas and we are to determine whether it is Hydrogen or Oxygen The gas is found to be colourless, tasteless and without any smell As these are common properties of Hydrogen and Oxygen, we are unable to decide which one the jar contains So we may make an experiment We introduce a glowing stick into the jar and find that the gas begins to burn This shows that inflammability is a property of the gas in the jar As this property is to be found only in Hydrogen and not in Oxygen, this experiment decides conclusively that the gas in the jar is Hydrogen, and not Oxygen

(2) *Galileo's experiment at Pisa* It was supposed that material bodies fell to the ground with a velocity proportional to their weight, Galileo maintained the opposite

hypothesis, *viz*, that the weight of bodies was irrelevant to the rate at which they fell By dropping cannon balls of unequal weight from the top of the leaning tower of Pisa and observing that they reach the ground at the same time, Galileo's hypothesis was proved, and the other hypothesis was disproved.

3 A Hypothesis should not only explain facts for which it is framed but also other facts.

3. Another test of a hypothesis is what Whewell calls "Consilience of Inductions".

"*Consilience of Inductions*" means the property which a hypothesis possesses of explaining facts other than those for the explanation of which it is framed. If a hyyothesis be framed for the explanation of a certain class of phenomena, and it is found that it not only explains them but also many other facts as well, its value is further increased For example, when we find that the theory of Gravitation not only explains the falling of bodies on the earth, but also explains the tides of the sea, the movements of the planets, it is proved better still.

4 A Hypothesis should have the power of prediction.

4. Whewell mentions another test, viz., a true hypothesis must have the power of prediction.

The power of prediction is an additional test of the excellence of a hypothesis Thus astronomers predict eclipses long beforehand with precision The prediction of the position of Neptune is also a remarkable instance of prediction by a hypothesis. It should be pointed out, however, that this by itself is not a conclusive test of a hypothesis. The Ptolemaic theory also could predict the phenomena of eclipses and the movements of the heavenly bodies to some extent, but it was found to be erroneous.

To sum up · In order to prove a hypothesis, it must be *verified*, it must be *adequate* to explain the

phenomena under investigation and should be the *only hypothesis* to do so, it should not only *explain* facts in its own sphere but also *other facts;* and lastly, it must *possess the power of prediction.*

Note 1. Explanatory and Descriptive Hypotheses.

To sum up: Hypothesis of Cause and Hypothesis of Law

A Hypothesis assumes three forms, hypothesis concerning an *agent,* hypothesis concerning a *collocation,* and hypothesis concerning the *law* of the operation of an agent. The agent and the collocation taken together constitute the cause Hence, we can speak of *two* forms of hypothesis, *viz, Hypothesis of Cause,* and *Hypothesis of Law.*

Explanatory Hypothesis is hypothesis concerning Cause while *Descriptive Hypothesis* is hypothesis concerning Law; but there is no essential distinction between the two.

Hypothesis of Cause, i e., every supposition of an antecedent circumstance as the real cause of the phenomenon in question, is called an **Explanatory Hypothesis,** because it offers an explanation of the phenomenon *Hypothesis of Law,* on the other hand, is called a **Descriptive Hypothesis,** because it describes the manner in which the phenomenon under investigation occurs. Thus *an explanatory hypothesis explains a phenomenon by assuming a cause, while a descriptive hypothesis describes the law of the operation of the cause* It should be noted, however, that there is no opposition between the two In fact, the so-called descriptive hypothesis or Hypothesis of Law, by describing the manner in which a phenomenon occurs, reveals to us, at least to some extent, the true nature of its cause, and in that sense, is explanatory. Hence, we conclude that there is *no esential distinction* between a descriptive hypothesis and an explanatory hypothesis, and that, strictly speaking, all hypotheses are explanatory, inasmuch as they are provisional suppositions for the explanation of phenomena.

Note 2. Working Hypothesis.

Working Hypothesis is an inadequate hypothesis, framed for want of a better one.

Some hypotheses, whether they are hypotheses concerning causes or laws, may be recognised from the very beginning to have very little probability. It may be that there is some phenomenon to be explained but it is of such an unfamiliar kind, that we are not

able to make any supposition at all as to its cause or law of operation. But some provisional supposition is necessary in order that we may study its nature and attributes. In such cases, we take the help of what are called Working Hypotheses. *A Working Hypothesis, therefore, means a provisional supposition, which though known to be inadequate, is still accepted as true, for the time being, because in the absence of a better hypothesis, it is useful as a guide to further enquiry.* Thus to suppose that Electricity is a *fluid* of some sort is an instance of a Working Hypothesis. This hypothesis, though scarcely probable, is better than none, the best perhaps under the circumstances

Note 3. Representative Fictions.

Representative Fictions represent things which cannot otherwise be conceived.

This expression was coined by **Bain**. To quote his words: "Some Hypotheses consist of assumptions as to the minute structure and operations of bodies. From the nature of the case, these assumptions can never be proved by direct means. Their only merit is their suitability to express the phenomena. They are *"Representative Fictions"*.

"All assertions as to the ultimate structure of the particles of matter are, and ever must be, hypothetical Yet we must not discard them because they cannot be proved; the proper criterion for judging of their value is their aptness to represent the phenomena That Heat consists of motions of the atoms can never be directly shown; but if the supposition is in consistency with all the appearances, and if it helps us to connect the appearances together in a general statement, it serves an important intellectual function" [BAIN, Part II, p 132]

One of the conditions of a legitimate hypothesis is that the supposed agent or cause must be *vera causa*. This does not mean a cause which must be perceptible by the senses but something which doe

not involve self-contradiction, and which may reasonably be believed to be existing. Representative Fictions are *vera causa* in that sense.

Sec. 8. Hypothesis and Abstraction.

The word 'Hypothesis' is sometimes used to mean Abstractions, as opposed to actual or concrete objects In this sense, it has been said by **Dugald Stewart** and others that geometrical reasonings are built upon hypothesis In Geometry, for instance, a 'point' is defined as something which has position but no magnitude, a 'line' is defined as that which has length but no breadth, and so on A real point, however, possesses besides some position, a certain magnitude, a certain colour and so on A real line certainly possesses breadth as well as length. In these cases, we make an abstraction of all the attributes except one In considering a point, we leave out of account other attributes and assume or suppose that it possesses position only. This sort of Abstraction has been called hypothesis, because, an Abstraction involves the *supposition* that it represents real things. In Hypothesis, in its ordinary meaning, we make a supposition, and in Abstraction, also, we make a supposition But the fundamental difference between an Abstraction and a Hypothesis is that a *Hypothesis is a supposition regarding something unknown, while in Abstraction we merely suppose that it stands for the real thing, by overlooking other features of the latter* Hence it is improper to call abstractions, hypotheses. As **Carveth Read** says: "This seems a needless and confusing extension of the term; for an hypothesis proposes an agent, collocation, or law hitherto unknown; whereas abstract reasoning proposes to exclude from consideration a good deal that is well known There seems no reason why the latter device should not be plainly called an **Abstraction**".

Dugard Stewart identifies Hypothesis with Abstractions

Such a meaning of the term 'Hypothesis' is improper.

Carveth Read.

Sec. 9. Use of Hypothesis.

A Hypothesis is a provisional supposition for the explanation of phenomena, and in order that it may be accepted as the starting-point of scientific investigation, it must fulfil certain conditions and become 'legitimate'. Further, sometimes legitimate

hypotheses cannot be framed because, the subject-matter of investigation is one of a wholly unfamiliar kind, and in such cases, we have to remain content with suppositions, admittedly imperfect, in the form of Working Hypotheses. This is necessary, because without some sort of supposition, no scientific enquiry can begin at all. From this it is clear that Hypotheses have the following uses in scientific investigations :—

1 Hypothesis is the starting-point of Induction and

1. Hypothesis forms the starting-point of scientific investigation, and makes Observation and Experiment possible.

Scientific Induction aims at the establishment of a causal connection. In order that a causal connection may be established, we must start with a provisional supposition as to what the Cause is or how it operates; and this is what is meant by Hypothesis.

controls Observation and Experiment

Hypothesis controls our observations and experiments from the very beginning. Observation and Experiment supply the materials or premises of Induction and these premises are the particular facts of experience. From these particular facts, a general law is to be established. There is something in these particular facts which binds them together, though, in other respects, they are different How are we to establish this bond of unity? Nature presents facts in a state of confusion, and if Observation is to detect the bond of unity, it must not be random perception but well-regulated perception, according to a definite purpose In other words, it must be guided by a provisional supposition as to what the bond of unity might possibly be. If Observation be impossible

without Hypothesis, Experiment is still more so. In Experiment, we artificially reproduce things under known conditions. Such artificial reproduction has for its object the verification of some supposition. For instance, we suppose that Hydrogen and Oxygen mixed in definite quantities will produce Water. We perform the experiment and find that the supposition is correct Sometimes, in a given case, a supposition may be falsified. But in all cases, Experiment requires some supposition to be tested. Thus, both Observation and Experiment are controlled by Hypothesis.

2. Hypothesis makes Deduction possible.

2. Hypothesis makes Deduction possible.

There are cases where the results of Observation are uncertain, and Experiment cannot be employed. In such cases, the only way to prove a causal connection is to suppose some principle, and deduce consequences from it and compare them with actual facts of experience.

3. Hypothesis is an aid to Explanation.

3. Hypothesis is an aid to Explanation.

Hypothesis is an attempt to explain the phenomena of Nature A phenomenon is explained when its cause or the law of its operation is proved. Hypothesis assumes three forms, *viz.*, hypothesis concerning an *agent* or a *collocation*, or the *law* of the operation of a known agent. In each case, the phenomenon is explained when the hypothesis is proved.

In our attempt at explanation, when the phenomenon presented is wholly of a novel nature, and a strictly logical hypothesis cannot be framed, sometimes we have to be content with what are known as Working Hypotheses. Such hypotheses are admittedly unsatisfactory and inadequate, but still they are

better than no hypotheses at all, because, they offer some explanation of the phenomenon. Thus Electricity is explained by supposing it to be a fluid. Though this supposition is unsatisfactory, yet it helps us in explaining the law of its behaviour to some extent. From this point of view, even a wrong hypothesis which is ultimately disproved, may offer a provisional explanation and may be useful to that extent. Thus the Ptolemaic theory which considered the Earth as the centre of the universe was not wholly useless, inasmuch as it explained various astronomical changes, though it was ultimately supplanted by the theory of Copernicus (See p. 138 & p. 147).

EXERCISE IV.

1 Define a hypothesis What are the conditions of a legitimate hypothesis?

2 What different kinds of Hypotheses are there? Give examples Explain how Hypotheses contribute to scientific discovery, citing instances.

3 What is Hypothesis? Give an example from common life What are the conditions of a valid Hypothesis?

4 Give the canons to which a good hypothesis must conform and illustrate them.

5 What do you understand by (1) crucial experiment, (2) theory, (3) Hypothesis, (4) *vera causa* and (5) Representative Fictions?

6 Discuss any distinction that may be drawn between verification and proof of a hypothesis

7 What is meant by Hypothesis in Science? What are its different forms? State and illustrate the uses of Hypothesis.

8 Explain the nature of Hypothesis What are the chief requisites of a valid Hypothesis?

9 Given a verifiable Hypothesis, what constitutes its proof or disproof?

10 What is the relation of Hypothesis to Induction? Explain and illustrate (*a*) working, (*b*) descriptive, and (*c*) explanatory hypothesis.

11 Explain and distinguish—Hypothesis, Theory and Fact

12 Does hypothesis play any part in assisting Observation?

13. Illustrate the uses of Hypothesis and explain how it aids Induction.

14. Distinguish between Hypothesis and Theory Explain the relation between Hypothesis and Induction What is a valid Hypothesis?

15. A man is found on a railway track wounded and lifeless. Frame two hypotheses about the cause of his death.

16. Give examples of (*a*) hypothesis about unknown agent, (*b*) hypothesis about the mode of operation of known agent, (*c*) verifiable hypothesis Does the verification of deductions from a hypothesis turn it into a certainty?

17. What are the characteristics of a legitimate Hypothesis? How does a legitimate hypothesis differ from Scientific Induction? Give illustrations.

18. If there be a theft in your room, how would you proceed to frame hypotheses (*a*) as to the identity of the thief and (b) as to the manner in which theft was committed?

19 Explain the relation between induction and legitimate hypotheses When is an hypothesis said to be valid?

20. Distinguish between a Working Hypothesis and a legitimate Hypothesis.

21. Distinguish between a Working Hypothesis and an established hypothesis.

22 What seems to you a satisfactory proof of a hypothesis?

23. If a hypothesis is found to contradict a fact, must it be forthwith abandoned?

24. Explain and illustrate—*experimentum crucis*

25 Explain the use of Hypothesis in scientific investigation.

26. Do hypotheses assist observation in any way? If so, how? What are the other uses of Hypothesis? Distinguish between a working hypothesis and a descriptive hypothesis.

27 What precisely is the relation of hypothesis to Explanation?

28. What are the circumstances favourable to Discovery?

29 Explain and illustrate the respective meanings of the terms (*a*) 'Fact', (*b*) 'Theory', (*c*) 'Law' (*d*) 'Hypothesis'.

30 Explain· "To identify the verification of a hypothesis with its proof is to commit the fallacy of consequent."

31 Is Hypothesis an essential factor in Inductive investigations? When is a Hypothesis raised to the position of Induction?

32 What constitutes proof or disproof of a verifiable hypothesis? When is a hypothesis said to be legitimate?

33. Can there be an induction without a prior *hypothesis*? What are the conditions and uses of a valid hypothesis?

CHAPTER V

The Experimental Methods and their Practical Applications.

Sec. 1. The Experimental Methods.

The Experimental Methods are devices by which causal connections are discovered and proved

Scientific Induction aims at the discovery and proof of a causal connection among phenomena* with a view to establishing a general proposition. Now, Logicians have formulated certain "methods" or devices by which causal connections among phenomena are investigated i.e., by means of which causes and effects of given phenomena are discovered and proved These methods of causal investigation have been called *Inductive Methods*, *Experimental Me-*

*Phenomenon—*singular* Phenomena—*plural*. The term 'phenomenon' (lit—that which appears) is used synonymously with "fact" and "event" to signify anything which can be observed; for example an explosion, the falling of an apple, the setting of the sun, etc.

thods, Methods of Experimental Inquiry, Inductive Canons, or *Canons of Direct Induction.*

Mill formulates *five* "Experimental Methods", *viz.*, the Method of Agreement, the Method of Difference, the Joint Method of Agreement and Difference, the Method of Concomitant Variations, and the Method of Residues. Of these five methods, only two, *viz.*, the Methods of Agreement and Difference are the fundamental methods, and the remaining three are subsidiary methods. Thus, the Joint Method of Agreement and Difference is simply a special modification of the Method of Agreement; the Method of Concomitant Variations may be a special form, either of the Method of Agreement or of the Method of Difference, according to circumstances; and lastly, the Method of Residues is a peculiar modification of the Method of Difference. Of the two fundamental methods, again, the Method of Difference is the more important, because, while the Method of Agreement is essentially a method of observation and only *suggests* rather than proves a causal connection, "it is by the Method of Difference alone that we can, ever, in the way of direct experience, arrive with certainty at causes." Some modern Logicians e.g., **Mellone, Coffey,** have added a new method, called by them, the Joint Method of Difference and Agreement. Mill's Five Methods.

It may be pointed out that though it was **Mill** (1806-1873) who for the first time gave an elaborate treatment of the "methods", it was not he who had discovered them **Bacon** (1561-1626) anticipated the Methods of Agreement, Difference and Concomitant Variations in his Table of Presence, Table of Absence and Table of Degrees respectively, though certainly he did not realise anything like the precision of Mill's methods. **Herschel** (1792-1871) however, in his *Preliminary Discourse on the Study of Natural* Bacon. Herschel.

Philosophy laid down *'Nine Rules* of Philosophising', and Mill admittedly drew his methods from them. It is to the credit of **Mill,** however, that he for the first time clearly defined the methods in great detail and pointed out their importance in the investigation of causes.

Mill. The Experimental Methods are not merely "weapons of elimination" but also devices for proving causal connection.

The "Experimental Methods" have been called by Mill, the **"Methods of Elimination."** Elimination means the exclusion of accidental circumstances. Thus Elimination is a process of negation merely. To describe the Experimental Methods as "methods or weapons of Elimination" merely would imply that their function is purely negative, that they are concerned merely with the exclusion of accidental and irrelevant circumstances As a matter of fact, however, the Experimental Methods have a positive as well as a negative character. *Negatively,* they may be described as "methods of elimination", because with their help accidental circumstances are excluded. But *positively,* their function is the discovery and proof of a causal connection. Elimination is not an end in itself—it is a means to an end. The end is the discovery and proof of a causal connection, and accidental circumstances are eliminated in order that essential circumstances may be brought out and determined Hence *the true function of the Experimental Methods is the discovery and proof of a causal connection by Elimination.* "Induction seeks not the mere elimination of a non-cause but the establishment of a cause" Thus the Experimental Methods are rules of applying Observation and Experiment, in order to eliminate the accidental factors and thereby to select one phenomenon, and to prove that phenomenon to be the cause or the effect of another phenomenon, *viz.,* the subject-matter of investigation.

Note.—The name "Experimental Methods" is misleading, inasmuch as it appears to signify that they make use of Experiment only, as distinguished from simple Observation. As a matter of fact, however, the methods make use of both Observation and Experiment The 'methods' are called "experimental", because, they are based on *experience* which includes both Observation and Experiment. Thus when they are spoken of as "methods of *experimental* enquiry," the term 'experimental' is equivalent to 'experiential' *i e*, methods of inference from experience generally, and not merely from Experiment. The Method of Agreement, for example, is mainly a method of Observation.

The name, 'Experimental' Methods, is misleading—they not only make use of Experiment but also of Observation.

Sec. 2. Principles or Canons of Elimination and their relation to the Experimental Methods.

Elimination consists in the exclusion of irrelevant factors in order that a causal connection may be discovered and proved Now the question is—What are the principles or rules which govern the process of elimination?

Bain points out that *the principles of Elimination are deductions from the Law of Causation* They are derived from the very definition of Cause **Mill** defines Cause as "the invariable and unconditional antecedent" The Cause is that without which a phenomenon would not occur. From this definition, the following principles forming the groundwork of the process of Elimination are deduced.

Three principles follow from the Law of Causation:—

(1) "Whatever antecedent can be left out, without prejudice to the effect, can be no part of the Cause."

(1) If a circumstance can be left out without affecting the effect, it is not the cause.

The Law of Causation states that a cause is that which produces an effect As the cause is present, the effect follows, and as the cause is absent, the effect is absent. According to the Law of Causation, it is impossible that the cause is absent and yet the effect is present. Hence, we may be certain that anything which can be omitted or left out, without making any difference to the effect in

question, cannot be its cause If we cut a string, which we think to be the cause of the support of an object, and yet the object remains in its original position, the string is not the cause of its support

This principle forms the basis of *the Method of Agreement*. According to this method, a certain phenomenon remains even after all the antecedents except one are left out, and this leads us to the inference that the omitted antecedents are not the causes, but the uniform antecedent is.

(2) If a circumstance cannot be left out without affecting the effect it is the Cause.

(2) "When an antecedent cannot be left out, without the consequent disappearing, such antecedent must be the cause or a part of the cause".

This principle also is involved in the Law of Causation. If some circumstances be left out and the effect disappears, then, there must be a causal connection between them. If we cut a string, which we think is the Cause of the support of an object, and the object falls down, then the string is the cause of its support This principle is the basis of *the Method of Difference.*

(3) If two circumstances vary together, they are causally connected.

(3) "An antecedent and a consequent rising and falling together in numerical concomitance are to be held as Cause and Effect".

This principle is involved in Causation, understood in its quantitative aspect According to the Law of the Conservation of Energy, the effect is the cause redistributed, and hence, if there be any quantitative variation in the cause, there must be an accompanying variation in the effect. This principle forms the basis of the *Method of Concomitant Variations.*

(4) If the influence of known causes is left out of account what remains of the effect is due to what remains of the cause

(4) **Bain** points out that these three are the principal methods, but after some progress has been made in the discovery of causes, a further principle may be formulated, *viz, if we allow for the influence of all known causes, we may attribute what remains of the effect to what remains of the cause.* This principle has been stated by **Joseph** as follows.—

"Nothing is the cause of a phenomenon which is known to be the cause of a different phenomenon"

This principle also follows from the Law of Causation, and forms the basis of the *Method of Residues.*

Sec. 3. The Method of Agreement.

Mill states the **Canon of the Method of Agreement** as follows:—

Canon

"If two or more instances of the phenomenon under investigation have only one circumstance* in common, the circumstance in which alone all the instances agree is the cause (or effect) of the given phenomenon".

Principle of the Method

As Mill points out, this method of discovering and proving a causal connection is based on the following principle: *"Whatever circumstances can be excluded without prejudice to the phenomenon is not connected with it in the way of causation"*. If some circumstance be left out, and yet the given phenomenon is present, there cannot be any causal connection between them. According to this method, from this principle, it follows that if some circumstance be always present, when the given phenomenon is present, there *is* a causal connection between them.

Hence **Carveth Read** amends Mill's enunciation thus: "If two or more instances of a phenomenon under investigation have only one other circumstance (antecedent or

* It is clear that by 'only one circumstance in common' Mill means one circumstance, *besides the phenomenon under investigation.* Of course, the phenomenon under investigation is common to all the instances If the phenomenon under investigation be the cause, it is common to all the antecedents; and 'only one circumstance in common' refers to a common consequent If the phenomenon under investigation be the effect, it is common to all the consequents; and 'only one circumstance in common' refers to a common antecedent Hence, 'one circumstance' means "one *other* circumstance", antecedent or consequent, as the case may be

consequent) in common, that circumstance is probably the cause (or an indispensable condition) or the effect of the phenomenon, or is connected with it by causation".

The Method of Agreement is employed to find out the effect of a given cause as well as the cause of a given effect.

Let us now attempt to explain the Canon of the Method of Agreement fully. We have a phenomenon under investigation, i.e., we want to ascertain its cause or effect. If the given phenomenon be an effect, we want to ascertain its cause, if, on the other hand, the given phenomenon be a cause, we want to find out its effect. In applying the Method of Agreement, we take '*two or more instances of the phenomenon under investigation*', i.e., by means of Observation, we collect several instances in which the given phenomenon occurs. The given phenomenon is common to all these instances, but in other respects they are different. *If the given phenomenon be the effect,* and we want to find out its cause, we collect by means of Observation, *antecedents* of the instances in which the given phenomenon occurs. When we do so, we observe that *these antecedents have 'only one circumstance in common'*, while they differ in other respects. From this we conclude that the invariable and common antecedent is the cause of the given phenomenon. *If the given phenomenon be the cause,* and we want to find out its effect, we collect by means of Observation, *consequents of the instances* in which the given phenomenon occurs. We then observe that *these consequents have 'only one circumstance in common'*, while in other respects they are different. We then conclude that the invariable and common consequent is the effect of the given phenomenon. The differing circumstances which are sometimes absent, and yet the given phenomenon is present, cannot have any causal connection with it. Thus the Method of Agreement sums up the following two propositions (i) *The sole invariable antecedent of a phenomenon is its cause, and* (ii) *The sole invariable consequent of a phenomenon is its effect.*

Symbolical Example

To take a **symbolical example :—**

A B C.................................. a b c

A D E.................................. a d e

A F G.................................. a f g

A is the cause of a, or a is the effect of A.

In the above illustration, the capital letters denote the antecedents, and the small letters, the consequents.

Suppose the given phenomenon is an effect, a. We *want to find out its cause* We collect several (say, three) instances in which *a* occurs *viz*, *abc*, *ade*, and *afg*. The cause of *a* must lie among its antecedents, and hence by means of Observation, we collect the antecedents of the three instances and find they are respectively, *ABC*, *ADE*. *AFG* These antecedents have one circumstance in common *viz*, A, while in other respects they differ The differing circumstances, *B*, *C*, *D*, *E*, *F*, *G* cannot be the cause, because they can be absent without affecting the effect *a* Therefore, the invariable and common antecedent *A* is the cause.

Suppose the given phenomenon is a cause, A. We want to find out its effect We collect several instances in which *A*, the cause occurs *viz*, *ABC*, *ADE* and *AFG*. The effect must lie among the consequents, and hence, by means of Observation, we collect the consequents of the three instances and find that they are respectively, *abc*, *ade*, *afg*. These consequents have *a* in common while they differ in other respects. Hence. the invariable and common consequent *a* is the effect

To take **concrete examples:—**

Concrete Examples.

1. From effect to cause.

(*a*) Suppose we want to find out the cause of a disease, say, *Malarial fever* We collect several instances where it occurs We find on Observation, that every one of these cases is preceded by the bite of anopheles, a particular species of mosquitoes, while other circumstances are different; for example, persons attacked have different habits. take different kinds of food, live in different places and so on Hence the common antecedent, *viz.*, the bite of anopheles, is the cause of malarial fever.

(*b*) *Mill's example*: Suppose we want to find out the cause of the effect, *Crystallisation* We compare instances in which bodies are known to assume crystalline structure but which have no other point of agreement Now Observation shows that these instances have only one antecedent in common *viz* solidification of a substance from a liquid

state. We conclude, therefore, that solidification of a substance from a liquid state is the cause of crystallisation

2. From cause to effect.

(*a*) Suppose we want to ascertain *the effect of a change of air* We collect by Observation several instances of persons who visit health resorts during holidays. We find that they come back from their holiday trips with more or less improved health, though they possibly had been suffering from different complaints From this we conclude that a general improvement in health is the effect of a change of air

(*b*) *Mill's Example* Suppose we want to find out the effect of the *contact of an alkaline substance and oil.* We collect by Observation several instances where this contact occurs We find that in every such case, soap is produced Hence we conclude that the production of soap is the effect of the contact of these substances

Why this method is called the Method of Agreement, or the Method of Single Agreement

This method has been called by Mill, "the Method of *Agreement*", because, "*this method proceeds by comparing different instances to ascertain in what they agree*" It should be pointed out, however, that it is not in the agreement alone that the proof consists, but in the agreement in one circumstance, compared with difference in all the other circumstances It is the *singleness of the agreement* that constitutes the proof Hence some Logicians, *e g.*, **Mellone, Coffey,** call this method **"the Method of Single Agreement."**

It is essentially a method of Observation

The Method of Agreement is pre-eminently a Method of Observation, as distinguished from Experiment This description does not mean that the Method of Agreement is limited to Simple Observation merely, and cannot be applied to cases where Experiments are possible Experiment does not exclude Observation, and wherever Experiment is

possible Observation is certainly possible, though the converse is not true. Hence the Method of Agreement can certainly be applied in cases of Experiment also. To say that it is "pre-eminently a method of Observation" means that *it is applied to those cases where our control over the phenomenon under investigation is so limited that Experiments are not possible.* It is a method to which we have recourse when we cannot experiment. The Method of Agreement does not require instances of any special and definite character. Any instance in which the phenomenon under investigation occurs may be examined for the purposes of this method Hence Observation can supply its instances The Method of Difference has been described as pre-eminently a method of Experiment, in the sense that for this method it is necessary to have instances of a special kind, and it is only Experiment and not Observation that can furnish such instances.

Advantages of this Method:—

As a method of Observation, the Method of Agreement possesses certain **advantages** over other methods. *The range of Observation is wider than that of Experiment,* i.e., there are fields of investigation which are absolutely beyond our control and cannot be made the subject-matter of Experiment. Hence the Method of Agreement can be applied to all the various fields of investigation. Moreover, by Observation, we can not only find the effect of a given cause but also the cause of a given effect. Hence the Method of Agreement is *applicable to the discovery and proof of the causal connection in both directions,* from the cause to the effect as well as from the effect to the cause. In these respects, the Method of Agreement is superior to other methods.

(i) Its range of application is wider than that of methods of Experiment.

(ii) It proves effects of causes as well as causes of effects.

Defects

Defects of the Method of Agreement and how far it is possible to overcome them.

The Method of Agreement labours under the following defects or limitations:—

1. Plurality of Cause vitiates the Method of Agreement

1. Characteristic Imperfection: The Method of Agreement is liable to be frustrated by the Plurality of Causes. This defect is called by Mill, the "*characteristic imperfection*" of the method, because it goes to the very root of things, and makes the results arrived at by the application of this method wholly uncertain.

The doctrine of the Plurality of Causes states that the same effect may have different causes on different occasions. If that be so, it may be that the effect whose cause we want to ascertain has different causes in the different cases observed, and the invariable and common antecedent has nothing whatever to do with the effect. Thus suppose that three different poisons mixed with water are given to three different animals, and they die. We cannot argue that the common circumstance, *viz.*, the presence of water, is the cause of death On the other hand, the three different poisons are the different causes of death in the three different cases. Similarly, if different kinds of purgatives each mixed up with rose syrup are used, and the effect is looseness, we are not to conclude that the common circumstance, *viz.*, the rose syrup is its cause Thus *the doctrine of the Plurality of Causes frustrates the Method of Agreement.* It is true that the doctrine is, strictly speaking, unsound but it presents considerable practical difficulties in cases where we are limited merely to simple Observation

The difficulties arising out of the Plurality of Causes can be partially overcome in two ways, *viz*, by the (i) Multiplication of instances and (ii) the application of the Joint Method, thus — How to overcome Plurality of Causes? Two ways —

(i) *Multiplication of Instances* One remedy of the failure of the Method of Agreement due to the Plurality of Causes is the Multiplication of instances If we take a large number of instances and find that one circumstance is present in all of them, our conclusion that it is causally connected with the phenomenon becomes highly probable It can hardly be true that in all these numerous instances the common circumstance is accidentally present Hence the greater the number of instances examined in the Method of Agreement, the greater the probability of the conclusion being true Nevertheless, the conclusion is never absolutely certain Thus the multiplication of instances helps us in overcoming the difficulties arising out of the plurality of causes to a certain extent but it does not radically cure the defect (i) Multiplication of instances

(ii) *Application of the Joint Method* The Joint Method is a distinct improvement on the Method of Agreement, inasmuch as it takes note of negative instances as well as of positive instances The positive instances show that the given phenomenon is present and one other circumstance is present; the negative instances show that the given phenomenon is absent and that the other circumstance is also absent. In order to obviate the difficulty of Plurality of Causes, the negative instances in the Joint Method are made sufficiently exhaustive, so as to contain all the circumstances other than what is uniformly present in the positive set. If these circumstances are present and yet the effect does not occur, they cannot be causes Hence the application of the Joint Method helps us in overcoming the difficulties arising out of the doctrine of Plurality of Causes (See Sec 4) (ii) Application of the Joint Method

2. Practical Imperfection : The Method of Agreement is subject to another difficulty in this that it is impossible to assure ourselves that we know all the antecedents. There is always the possibility that there is some hidden circumstance 2 The possibility of hidden or unknown circumstances also vitiates the

Method of Agreement.

which has escaped us; in other words, we are liable to commit the fallacy of Non-observation This defect has been called the *"practical imperfection"* of the Method of Agreement.

As the Method of Agreement is essentially a method of Observation, we cannot be certain that all necessary circumstances have been observed. We may think that we have observed that a certain circumstance is the only constant circumstance but there may be some other circumstance which also is constantly present but which was not observed, and it is that circumstance which is causally connected with the phenomenon under investigation. This method requires instances which agree in one particular only This is a demand which in practice can hardly be fulfilled because we draw our instances from simple Observation

This practical imperfection of there being unobserved necessary circumstances can be overcome only to some extent by the *multiplication of instances* If we take a large number of instances into account, the chances are that all necessary circumstances would come to our notice but it must be admitted that we can never be absolutely certain of that Hence this difficulty cannot be wholly overcome

2 The Method of Agreement cannot distinguish causation from co-existence.

3. The Method of Agreement does not enable us to distinguish Causation from Co-existence.

Causation involves succession, and should not be confused with Co-existence. When two phenomena always go together, they need not be related as cause and effect but they may be co-effects of the same cause as in the case of day and night, heat and light, lightning, and thunder Hence the Method of Agreement fails to distinguish Causation from Co-existence.

We conclude, therefore, that the **Method of Agreement merely suggests but cannot prove a causal connection.** It should be regarded as a stage in scientific enquiry. As **Coffey** puts it: "Its chief utility lies in the fact that it suggests a causal connection as an hypothesis for verification." From this point of view, it has been said that the Method of Agreement is *a method of Discovery* rather than a method of Proof.

The Method of Agreement cannot *prove* causal connection but merely *suggests* it. Hence it is a method of Discovery rather than of Proof.

Note. The Method of Agreement and Induction per Simple Enumeration.

Induction per Simple Enumeration is arriving at a general proposition on the basis of uncontradicted experience Experience furnishes us with a number of instances in which two phenomena are found together, and no contrary instance is known to exist and from this uncontradicted experience, we conclude that they always go together. So far as our experience goes, ravens have been found to be black, no raven of any other colour has been met with, and from this we arrive at the Induction per Simple Enumeration that all ravens are black.

Induction per Simple Enumeration.

The Method of Agreement seeks to prove a causal connection between two phenomena, on the ground that experience furnishes a number of instances which agree in the presence of a certain circumstance, whenever the phenomenon under investigation is present. On observing a number of cases of malarial fever, and further observing that every such case has for its antecedent, mosquito-bite, we conclude that there is a causal connection between them.

The Method of Agreement.

Thus we find that in both cases, we collect by means of Observation a number of positive instances, which agree in the presence of two phenomena In both cases, the conclusion derives its support from the circumstance that there is a number of such instances, and the greater the number, the greater the probability of the conclusion Hence, one may think that Induction per Simple Enumeration is always an employment of the Method of Agreement. But such a

The difference between them is that in the Method of Agreement, we *select* instances

whereas in Simple Enumeration, there is no such selection.

view is erroneous, and there is an important difference between the two The Method of Agreement is an *experimental method* which seeks to *eliminate irrelevant facts by varying the circumstances* in order that a causal connection may be proved; whereas, in Induction per Simple Enumeration, there is no such elimination. In the Method of Agreement, we do not merely collect a number of instances of Observation, but we select certain instances and reject others Induction per Simple Enumeration does not select instances. Its validity depends merely on the *number* of instances which come to our experience. It does not pay any attention to the *character* of the instances. In the Method of Agreement, we depend not merely on the number of instances but more on their character We lay stress on the variety as well as on the number of the instances Hence as **Fowler** puts it· "A few well-selected instances are often sufficient to satisfy the requirements of the Method of Agreement The same number when we abstract the grounds on which they are selected, would be utterly insufficient to justify an *Inductio per Enumerationem Simplicem*"

Fowler.

Sec. 4. The Joint Method of Agreement and Difference.

Canon.

Mill states **the Canon of the Joint Method of Agreement and Difference as follows:—**

"If two or more instances in which the phenomenon occurs have only one circumstance in common, while two or more instances in which it does not occur have nothing in common save the absence of that circumstance, the circumstance in which alone the two sets of instances differ is the effect, or the cause, or an indispensable part of the cause, of the phenomenon".

The Joint Method is a double application

The Joint Method of Agreement and Difference is really *a double employment of the Method of Agreement*, thus:—

(*a*) We observe a number of instances in which the phenomenon under investigation is present, and

find that they *agree only in the presence* of a given circumstance. This is called the set of positive instances. (This is the Method of Agreement in its ordinary or *positive* form); and secondly,

of the Method of Agreement —agreement in presence and agreement in absence

(*b*) We also observe a number of instances, in which the phenomenon under investigation is absent, and we find that the circumstance which was uniformly present in the set of positive instances is the only thing which is uniformly absent here. This is called the set of negative instances*. (This may be said to be the *negative* form of the Method of Agreement, inasmuch as in this case, the instances *agree in the uniform absence* of the phenomenon under investigation as also of the other circumstance.)

This method is not recognised by Mill as an independent and distinct method of proof but only as an "extension and improvement of the Method of Agreement" The causal connection suggested by the Method of Agreement is confirmed by this method.

To take a **symbolical example**:

Symbolical Example

Agreement in presence (*Set of positive instances*).		Agreement in absence (*Set of negative instances*)	
A B C..	...a b c	B C D.	..... b c d
A C D ...	......a c d	D E F	.... d e f
A D E	......a d e	E F G	.... e f g

∴ *A* is the cause of *a*.

* It should be pointed out that the negative instances should resemble the positive instances as nearly as possible in every particular except the absence of the phenomenon under investigation and the other common circumstance They must therefore be of the same kind of fact It would not do to take any instance of the absence of the phenomenon

In the set of positive instances, A is uniformly present in the antecedents, and a is uniformly present in the consequents, in the set of negative instances, A is uniformly absent in the antecedents, and a is uniformly absent in the consequents According to the Method of Agreement, the set of positive instances suggests the conclusion that A is the cause of a This inference is confirmed by the set of negative instances in which A is uniformly absent in the antecedents, and a is uniformly absent in the consequents.

It should be understood that instances in the negative set in which the phenomenon under investigation does not occur must be of such a nature that if it were due to any cause other than the circumstance in question, those other causes would make their appearance The negative set shows that B, C, D, F, F, G cannot be causes of a, because they are present while the effect is absent

To take concrete examples:

Concrete Examples

(a) A man observes several instances in which he eats a particular article of food and suffers from indigestion From this set of positive instances, according to the Method of Agreement, he infers that the eating of that article of food is the cause of indigestion He then takes a set of negative instances, and finds that when he does not take that article of food, he does not get indigestion. In this way, his original conclusion is confirmed.

(b) It is observed that whenever a particular military general is personally conducting a battle, the army is victorious; whenever he is personally absent, the army suffers defeat. The inference is that the success of the army is due to the personality of the general

(c) *Mill's example* · We observe that Dew is formed on objects which radiate heat rapidly We also observe that Dew is not formed, (the phenomenon does not occur), on objects which agree only in the absence of rapid radiation of heat From this we conclude that the rapid radiation of heat is the cause of the formation of Dew

The Joint Method is also called the Indirect

This method is also called by Mill **"The Indirect Method of Difference"** because the negative instances are obtained not by experiment, but *"indirectly, by showing what would be the result if experiment could be made"*. It is also called the **Joint Method of Agreement and Difference.**

It is one of *agreement*, so far as the set of positive instances is concerned; the positive instances *agree* in the presence of the circumstance in question. **It is one of** *difference*, in so far as it considers both the positive **and** the negative sets of instances; the positive and negative **sets of instances** *differ* **in this that the circumstance in** question is uniformly present in the positive set and uniformly absent in the negative set. Some Logicians prefer to call this method, **"The Double Method of Agreement"** or **"The Method of Double Agreement,"** because, there is *double agreement*, agreement in presence and agreement in absence This is a better name for this method, and we should on no account confuse it with the Method of Difference.

Method of Difference, the Double Method of Agreement or the Method of Double Agreement

Like the Method of Agreement, the Joint Method is essentially a method of Observation (not of Experiment) and as such possesses all the advantages and disadvantages of Observation. The **advantages** are that both these methods have a wide range of application and can be employed in cases where the phenomenon under investigation is beyond our control. The **disadvantages** are that neither of them can conclusively prove a causal connection, though the conclusions of the Joint Method which takes note of negative instances are more probable than those of the Method of Agreement. The defects of the Method of Agreement are that it is frustrated by the possibility of a plurality of causes, by the possibility of there being hidden and unknown circumstances which escape our observation, and further, it is unable to distinguish causation from co-existence The Joint Method also suffers from the imperfection of there being hidden and unobserved factors and is unable to distinguish causation from co-existence. But **the Joint Method is more or less free from the difficulty arising out of the possibility of the Plurality of Causes.** In fact the Joint Method is specially designed for obviating the difficulties arising from a possible plurality of causes.

The Joint Method, like the Method of Agreement is a method of Observation Its advantages and disadvantages.

Does Plurality of Causes vitiate the Joint Method?

To take the following symbolical example of the Method of Agreement :—

A B C .... a b c
A C D. . . . . a c d
A D E .... a d e
∴ A is the cause of a.

This is vitiated by the possibility of a plurality of causes, because, it may be that in the first case *B* is the cause of *a*, in the second case *D* is the cause of *a*, and in the third case, *E* is the cause of *a*, and that the uniform presence of *A* in the antecedents is an accidental coincidence.

Let us now take the set of negative instances :—

B C D . . .. .b c d
D E F. ... . .d e f
E F G . . .. e f g

The first negative instance shows that *B*, *C* and *D* are present in the antecedents, and yet *a* is absent from the consequents. This shows that they cannot be the causes of *a*. Similarly, *E* cannot be the cause of *a*, as shown in the second negative instance and so on. Thus *if the negative instances are fully exhaustive and contain all the circumstances, other than what is uniformly present in the positive set, there cannot be a plurality of causes.* But if this condition is not fulfilled, the possibility of a plurality of causes does not disappear.

Sec. 5. The Method of Difference

Canon. **Mill** states **the Canon of the Method of Difference** as follows —

"If an instance in which the phenomenon under investigation occurs, and an instance in which it does not occur, have every circums-

tance in common save one, that one occurring only in the former; the circumstance in which alone the two instances differ is the effect, or the cause, or an indispensable part of the cause, of the phenomenon."

The principle of the Method.

The Method of Difference is based on the *principle that whatever cannot be eliminated without interfering with the phenomenon under investigation must be causally connected with the latter.* If a circumstance be left out and the phenomenon under investigation disappears, *everything else being the same,* there must be a causal connection between the two.

Explanation of the Canon.

In the Method of Difference, we take two instances and two instances only. Each instance is a group of antecedents followed by a group of consequents. The two instances differ only in one circumstance (antecedent or consequent as the case may be), which is present in the one and absent in the other. *In all other respects, the instances are exactly the same.* From this we conclude that the circumstance in which the two groups of antecedents differ is the cause of that circumstance in which alone the two groups of consequents differ.

Two forms:

It may be pointed out that the Method of Difference may assume two forms. We may *add* something to the antecedents, and the result is that something new happens in the consequents; or we may *subtract* something from the antecedents, and something disappears from the consequents. Hence **Mellone** states the Method of Difference as follows:—

Mellone

"When the addition of an agent is followed by the appearance, or its subtraction by the disappearance, of a certain event, other circumstances remaining the same, that agent is causally connected with the event".

This method is called the Method of *Difference* because on a comparison of the two instances which we take we find that they *differ* only in one respect. It is *the singleness of the difference* that constitutes the ground of proof, and hence, **Coffey** and **Mellone** call this method—**the Method of Single Difference**.

Agreement and *Difference* compared.

Thus while in the Method of Agreement the *several instances agree only in one respect* (in other respects they differ), in the Method of Difference, the *two instances differ only in one respect* (in other respects they agree).

Symbolical Examples

To take **symbolical examples :—**

(1)	A B C	a b c	(2) B C	b c
	B C	b c	A B C	a b c

∴ *A* is the cause of *a*.

In the first example, *A* is subtracted from the antecedents, and the result is that *a* disappears from the consequents; in the second example, *A* is added to the antecedents, and the result is that *a* appears in the consequents. Thus *A* is the only circumstance in which the two groups of antecedents differ Similarly, *a* is the only circumstance in which the two groups of consequents differ *Other circumstances are absolutely common* Hence we conclude that *A* is the cause of *a*.

Concrete Examples.

To take **concrete examples :—**

(*a*) If a bell is rung in a jar filled with air, the sound of the bell is heard, but if the same bell is rung in a jar from which the air has been pumped out, no sound is heard. Other circumstances remain the same Hence the presence of air is an indispensable part of the cause of sound.

(*b*) "When a man is shot through the heart it is by this method that we know that it was the gun-shot which

killed him; for he was in the fullness of life immediately before, all circumstances being the same except the wound"

(c) *The coin and the feather experiment.* When a coin and a feather are dropped simultaneously in the receiver of an air-pump, *the air being left in*, the feather flutters to the ground after the coin Then *the air is pumped out* of the receiver, and the coin and the feather being dropped at the same instant reach the bottom of the receiver together The single circumstance of difference is the presence of the air Other circumstances are the same Hence it follows that the resistance of the air is the cause of the feather falling more slowly than the coin

This Method plays a great part in our everyday inferences

The Method of Difference plays a great part in our everyday inferences. Thus a man is thirsty, he drinks water and his thirst is quenched. We strike a match stick against the side of a match box, and there is light and fire. The sun rises, and there is heat and light The sun sets and there is darkness. A careless use of the Method of Difference sometimes leads to the fallacy of **post hoc, ergo propter hoc** The appearance of a comet in the sky may be followed by the death of a king, but we certainly cannot argue that the appearance of the comet is the cause of the death Similarly, a particular man goes away from a village, and cases of theft disappear; we cannot from this circumstance alone infer that that man was the thief. In practical life, we depend on simple Observation for the supply of instances, but in such cases the Method of Difference does not yield conclusive results. In order to comply with the special requirements of this method the instances must be supplied by Experiment.

The Method of Difference is essentially a method of Experiment

The Method of Difference is essentially a Method of Experiment, because, it is only in experiment that we may be sure of having complied with the strict requirements of the method. The

because only Experiment (and not Observation) can furnish instances of the special kind required for this Method

essential requirement of this method is that the two instances must be exactly alike, except that in one, the phenomenon under investigation is present, and in the other it is absent. The instances required are thus rigid and definite. Only one circumstance shall be varied and all other circumstances must remain the same. Now we can never be sure that the instances furnished by Observation are instances of this special kind. For example, if this day is cooler than yesterday, we may think that last night's thunderstorm is the cause of the fall in temperature. But besides the thunderstorm, there were, say, rain and a change in the direction of the wind Hence, when we are limited to simple Observation, it is impossible to say that the requirements of the Method of Difference have been fully complied with Thus this method can be successfully applied only in the case of Experiment In Experiment, we have control of the conditions and are able to vary them at will, and as such we may be careful in introducing or removing only one circumstance at a time.

The Method of Difference proves causation conclusively, when strictly applied

From the above it follows that if the instances fulfil exactly the requirements of the Method of Difference, this method can conclusively prove causation. The Method of Agreement can be said only to *suggest* a causal connection, and not to *prove* it When a cause is suggested by the Method of Agreement or in some other way, we apply the Method of Difference to test and verify the supposed cause. If we find that the supposed cause cannot be introduced without a particular phenomenon occurring, or that the supposed cause cannot be withdrawn without the phenomenon disappearing, *all other circumstances remaining the same,* the supposed cause is proved to be the real

cause. Thus the special merit of this method is, as Mill points out, that it is the only method of direct experience, by which the laws of causation can be proved.

Thus the Method of Difference has the following **uses or advantages :—**

Advantages:

1. The Method of Difference is pre-eminently a method of Experiment and helps us in proving causal connection conclusively.

2. When applied experimentally, it supplies tests to confirm the conclusions arrived at by an application of the Method of Agreement.

3. It requires only two instances, although these two instances must be of a special kind.

The Method of Difference, however, is subject to the following **defects or limitations :—**

Defects:

(a) *The Method of Difference cannot be directly applied to reasoning from effect to cause.*

(a) By this method we cannot proceed from effects to causes.

The Method of Difference being essentially a Method of Experiment is subject to the limitations to which Experiment is subject. In Experiment, we can proceed from cause to effect, but cannot go backwards from effect to cause The effects are not within our control. We cannot add to them or subtract from them in the same way as we can add to or subtract from groups of causes When by this method, we want to find out the cause of an effect, we have to proceed indirectly by taking a supposed cause and then we examine whether the supposed cause produces the given effect. The Method of Agreement, however, being essentially a Method of Observation, can be employed to ascertain effects of causes as well as causes of effects

(b) The Method of Difference only proves that a certain circumstance is the cause of a phenomenon in a given case; but it cannot prove that it is the only cause and that there cannot be other causes on other occasions.

(b) The Method of Difference does not enable us to deal completely with Plurality of Causes.

The Method of Agreement is vitiated by the possibility of a plurality of causes, because the circumstance which is uniformly present may only be an accidental circumstance, whereas, the real cause may be different in the different cases. So far as the Method of Difference is concerned, it cannot be vitiated by the possibility of a plurality of causes in this sense. If by experiment, something is added to known circumstances, and something follows, every thing else remaining the same, the former is certainly the cause of the latter, and so far as this instance is concerned, the latter circumstance cannot have any other cause. But from this it does not follow that the latter circumstance cannot have any other cause *in other instances* Hence, the Method of Difference can only prove that a particular antecedent is the cause in a given case but cannot prove that it is the only cause, or that there cannot be other causes in other cases. It proves *a* cause but *not* that it is *the only cause.* Hence, we find that even the Method of Difference does not enable us to deal with the possibility of a plurality of causes completely

(c) It fails to distinguish a cause from a condition.

(c) The Method of Difference does not enable us to distinguish a cause from a condition.

The Method of Difference is defective in yet another respect. Granting that *BC* produces *bc*, will the introduction of *A* compel us to regard it as the sole cause of the new consequent *a*? Not necessarily, for *a* may be due to *A* combining with *B* and *C*. Thus we cannot say that the introduction of a new element is necessarily the sole cause of any change which may

happen. It may be one of the conditions merely. For example, if a dish of food be unpalatable, the addition of salt may render it palatable. But it does not follow that the agreeable taste is due to the salt alone. The salt is only one condition but there are other conditions which must be taken into account in order that the entire cause may be ascertained. Similarly, when we apply a glowing match stick to a heap of combustibles, the match stick is not the sole cause of the resulting conflagration. Mill recognises this when he says that the circumstance in which alone the two instances differ may be "an indispensable part of the cause".

Sec. 5A. The Joint Method of Difference and Agreement.

Mellone's Canon.

Mellone and **Coffey** have formulated a new Experimental Method called by them, the *Joint Method of Difference and Agreement.* **Mellone** states the Canon in the following words:

> "When one phenomenon has been shown to be *the cause of another under given conditions*, by the Method of Single Difference; and when we fail to find or to construct any instance where the one phenomenon occurs without the other; then it is probable that the first is the '*unconditionally* invariable antecedent' of the second—*i.e*, that the latter can be produced by no other way than by the former; and the probability increases with the number and variety of the negative instances all agreeing in the absence both of the effect and its suspected cause".

This Method as compared with the Method of Difference and

This Method presupposes the Method of Single Difference and supplements the latter. A causal connection between A and a is conclusively established when we succeed in proving

(i) If A, then a, and
(ii) If not A, then not a.

The Method of Single Difference proves the first proposition *i.e.*, A is a cause of a In order to prove further that A is

the *only possible cause* of *a*, it is necessary to conduct an investigation into all the material negative instances. "Material" negative instances are those which fall in the same department of investigation e g, if the field of investigation be Chemistry, the positive and negative instances must be sought in the department of Chemistry It is thus necessary to exhaust the field of negation by proving that 'if *A* is absent, *a* is absent' This Joint Method of Difference and Agreement supplements the Method of Single Difference by independently investigating the negative instances The "Difference" refers to the causal connection experimentally determined in the positive instances, the "Agreement" refers to the absence of the effect together with its suspected cause in *all* the negative instances examined

the Double Method of Agreement

Just as the Double Method of Agreement supplements the Method of Single Agreement, so this Joint Method of Difference and Agreement supplements the Method of Single Difference The distinction between the "Double Method" and this "Joint Method" is that while in the former, the positive and the negative instances are found by Observation, in the latter, they are found by Experiment In the Joint Method of Difference and Agreement, the negative instances have to be *constructed* i e, experimentally found in such a way that the cause cannot occur in any of them.

Sec. 6. The Method of Concomitant Variations

Canon.

Mill states the Canon of the Method of Concomitant Variations as follows :—

Whatever phenomenon varies in any manner whenever another phenomenon varies in some particular manner, is either a cause or an effect of that phenomenon, or is connected with it through some fact of causation."

Explanation.

This Method is based on the **principle** that *the cause and the effect being quantitatively equal in*

energy, increase or decrease in the one must be followed by a proportionate change in the other. Thus if two phenomena always vary together, they are causally connected. Of these two phenomena, one is the antecedent, and the other, the consequent. If they vary together, the antecedent is the cause of the consequent. Concomitant variation may be *direct variation*, in which the antecedent and the consequent vary in the same direction, *i.e.*, they rise and fall together; or *inverse variation*, in which the antecedent and the consequent vary in opposite directions, *i.e.*, the increase in the one is followed by the decrease in the other, and *vice versa*.

Symbolical Example

To take a **symbolical example** :—

A_1 B C. . ...a_1 b c
A_2 B C . . .. a_2 b c
A_3 B C.... ....a_3 b c
∴ *A* is the cause *a*

This Method is a modification of the Method of Difference, when the accompanying circumstances are the same but.

In this case, we find that two phenomena *A* and *a* are varying concomitantly. When *A* is increasing in the antecedents, *a* is increasing in the consequents and therefore, we conclude that *A* is the cause of *a* or that they are causally connected. In this case, we find that the accompanying circumstances *B* and *C* are the same. Hence, this illustration shows that the Method of Concomitant Variations is a special form of the Method of Difference. The instances differ in nothing else except in the concomitant variations of *A* in the antecedents, and of *a* in the consequents. It is clear that we can be certain that the other circumstances are the same, only when the instances are supplied by Experiment.

If the accompanying circumstances are different, it is a modification of the Method of Agreement.

Carveth Read, however, mentions another form of the Method of Concomitant Variations, in which the accompanying circumstances are not the same but different The following *symbolical example* will illustrate this form :—

A_1 B C . . . . a_1 b c
A_2 D E . . . . a_2 d e
A_3 E F... .. .. a_3 e f
∴ *A* is the cause of *a*

In this case, we find that the accompanying circumstances are changing from instance to instance and the only thing in which the instances agree is that an increase in *A* is followed by an increase in *a*. From this we conclude that *A* is the cause of *a* It is clear that in this case, the Method of Concomitant Variations is a modification of the Method of Agreement, and is subject to the imperfections of the latter method.

Thus *the Method of Concomitant Variations may be regarded as a modification of the Method of Difference or of the Method of Agreement, according as the accompanying circumstances are the same or different respectively.* In the former case, it is a method of Experiment while in the latter case, it is a method of Observation.

Concrete Examples.

To take **concrete examples :—**

(1) We observe that as Heat increases, the mercury in the thermometer expands in volume From this we conclude that Heat is the cause of expansion of Mercury

(2) Pascal proved by the employment of the Method of Concomitant Variations that the height of Mercury in the barometer depends on the weight of the atmosphere He went up a hill and of course as he ascended higher and higher, the weight of the atmosphere became less and less,

He observed that as the weight of the atmosphere became less and less, the height of the mercury in the barometer also became less and less. Hence he arrived at the conclusion that the weight of the atmosphere was the cause of the height of the mercury.

(3) Albert the Great (1206—1280) proved the causal relation between the moon and the tides by this method. He observed that variations in the size of the moon were concomitant with the ebb and the flow of the tide and hence concluded that there was a causal connection between the two.

(4) It is a common experience that the lower the price of a thing the larger is the quantity of it which is bought by consumers In other words, the demand of a commodity increases as the price decreases This is the result of what in Economics is called the Law of diminishing utility.

Special feature of the Method of Concomitant Variations.

This Method is applicable to cases, where complete elimination is not possible.

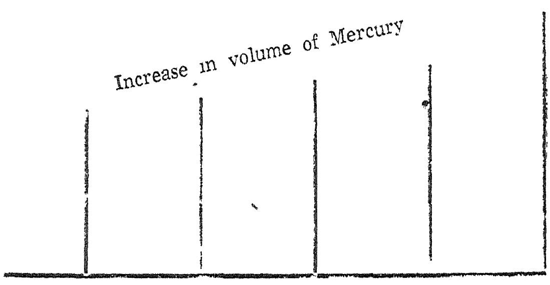
There are certain causes or agencies which cannot be wholly eliminated. These agencies are called by Mill, *Permanent Causes, e.g.*, heat, gravity, atmospheric pressure, friction, electric and magnetic influences, etc. We cannot deprive a body of all its heat—the nature of the agency precludes such a possibility. Similarly, we cannot get an instance in which gravity or atmospheric pressure is altogether absent. But though the complete elimination of these permanent causes is not possible, they vary in degrees and can therefore, be partially eliminated. The phenomena cannot be entirely got rid of but they appear in greater or less quantity. *The Method of Concomitant Variations is specially applicable to the determination of a causal connection in the case of these permanent causes,* which cannot be totally

eliminated but can be partially eliminated, because, they appear in varying degrees We take instances in which the phenomenon under investigation undergoes variations in degrees, and when we find that there are concomitant changes in some other phenomenon, we conclude that these two are causally connected. The Method of Difference can only be applied when there is complete elimination, *i.e.*, when the phenomenon under investigation is present in one instance, and wholly absent in the other instance Thus the Method of Concomitant Variations is applied to those cases where it is impossible to apply the Method of Difference.

Graphic representation of the Method.

Graphic Method.

The application of the Method of Concomitant Variations may be illustrated easily by what is called the **Graphic Method.** One of the varying phenomena is represented by a horizontal line, divided at various points The other varying phenomenon may be represented by a series of perpendicular lines of different length, according to the point of the horizontal line from which they start



The horizontal line represents Heat and the various points at which it is divided show increase in the degree

of heat. The perpendicular lines show the volume of Mercury in the column As the degree of Heat increases, the volume of Mercury in the barometer also increases.

Limitations of the Method of Concomitant Variations.

The Method of Concomitant Variations is subject to the following **limitations**:—

Defects·

(1) This Method has no application beyond observed facts

(1) *The Method of Concomitant Variations has no application beyond facts which have been actually observed.* According to the Method of Concomitant Variations we argue that when two phenomena are observed to vary concomitantly, they are causally connected. But from this we cannot argue that the variation will continue beyond observed limits. For example, we find that in some cases, Water expands under the influence of heat, and contracts when exposed to cold. As heat increases in intensity, Water increases in volume, and as heat decreases, Water contracts. But it would be erroneous to suppose that these variations hold good in all degrees. On the other hand, it has been experimentally ascertained that Water expands instead of contracting when it falls below a certain temperature, *viz.*, 39.4°F. Hence the Method of Concomitant Variations does not warrant us in making an inference beyond observed limits.

(2) This Method has no application to variations in Quality

(2) *The Method of Concomitant Variations has no application in cases of qualitative variations.* The Method of Concomitant Variations is applied to quantitative variations, *i e*, when two phenomena vary in degree. If, however, there is a variation in quality or kind, a new condition is introduced and this method is unable to cope with it.

Sec. 7. The Method of Residues.

Mill states **the Canon of the Method of Residues** thus :—

Canon.

"Subduct from any given phenomenon such part as is known by previous induction to be the effect of certain antecedents, and the residue of the phenomenon is the effect of the remaining antecedents."

Symbolical Example

To take a **symbolical example :—**

A B C	a b c	
B C	b c	(because B is known to be the cause of b, and C is known to be the cause of c).

∴ *A* is the cause of *a*.

We find that the complex event *abc* is caused by *ABC*. From previous inductions we already know that *B* is the cause of *b*, and *C*, is the cause of *c* By calculation we ascertain that *BC* is the cause of *bc*. The residue of the given complex event is *a* We conclude that the residue *a* is the effect of the remaining antecedent *A*.

Concrete Examples:

To take **concrete examples :—**

(i) We weigh a cart with load and note the weight. We already know the weight of the cart alone By subtracting the weight of the cart from the total weight of the cart with load, we conclude that the difference is the weight of the load

(ii) *Jevons' example* "In chemical analysis this method is constantly employed to determine the proportional weight of substances which combine together. Thus the composition of water is ascertained by taking a known weight of oxide of copper, passing hydrogen over it in a heated tube, and condensing the water produced in a tube containing sulphuric acid If we subtract the original weight in the condensing tube from its final weight, we learn how much water is produced; the quantity of oxygen

in it is found by subtracting the final weight of the oxide of copper from its original weight. If we then subtract the weight of the oxygen from that of the water, we learn the weight of the hydrogen which we have combined with the oxygen When the experiment is very carefully performed .. .. we find that 88 89 parts by weight of oxygen unite with 11 11 parts of hydrogen to form 100 parts of water"

This Method is based on the **principle** that *what is the cause of one thing cannot be the cause of a different thing.* When we are dealing with a complex set of phenomena, and we already know the cause of some of them, we conclude that the cause of the remainder or residual phenomenon is to be found among the remaining antecedents. The principle of the Method

CARVETH READ points out that in this Canon, the phenomenon is assumed to be an effect, and a similar canon may be framed for residuary-causes.

This Method is sometimes employed in a slightly different form. Instead of attributing the remaining consequent to the "remaining antecedent", we are led by the presence of the unexplained element in the phenomenon to seek its unknown cause **Mellone** formulates the following rule to cover such cases:— Mellone's Canon

"When any part of a complex phenomenon is still unexplained by the causes which have been assigned, a further cause for this remainder must be sought."

Suppose there is a complex phenomenon which has been partially explained but a part of which is still unexplained. We do not know the cause of this unexplained part or "residual phenomenon". We make further enquiries and succeed in finding out the cause. Thus, this Method becomes, to use Mellone's expression, *"a finger-post to the unexplained"*. The Method of Residues is a method of discovery

Applied in this way, the Method of Residues is *a method of discovery rather than of Proof.* It is a source of hypotheses rather than a means of testing and verifying them. The following **concrete examples** will illustrate this use of the Method of Residues —

Concrete Examples

(*a*) *Discovery of Argon.* Lord Rayleigh (1842-1919) and Professor Sir W. Ramsay (1852-1916) discovered a gas, *viz.*, Argon, in 1894 by the application of this method. It was observed that Nitrogen obtained from the air was slightly heavier than Nitrogen obtained from other sources. In searching for the cause of this difference in weight, they discovered that the increased weight was due to the fact that Nitrogen in the atmosphere was mixed up with another gas, till then unknown. Thus it was discovered that the presence of this gas, *viz.*, Argon, was the cause of the difference in weight.

(*b*) *Discovery of the planet Neptune.* Adams and Le Verrier discovered the planet Neptune by the application of this method in 1846. It was observed that the planet Uranus presented certain anomalies in its motion—that there was a slight deviation from the path, which according to calculations should have been its orbit. The influence of the Sun and the known planets on Uranus was calculated but it was found that as a matter of fact, Uranus did not follow the calculated path. This led to a search for the cause of the deviations and they were found to be due to the influence of another planet, till then unknown, *viz.*, Neptune.

This Method can be applied only when we have made some progress in our knowledge of causation.

The special feature of the Method of Residues is that it can be applied only when we have made some progress in our knowledge of causes—only when we have attained a certain stage in our inductive enquiries and proved certain facts of causation. When some complex phenomenon has been for the most part accounted for by known causes, and there remains some excess or deficiency or deviation, we apply this method.

The Method of Residues contains an element of Residues contains an element of Deduction

The Method of Residues contains an element of Deduction. In it, all that observation does is to show that certain antecedents are followed by certain consequents Then begins the process of calculation or deduction. We calculate the effects of known causes and subtract this calculated effect from the total effect In this way the residual consequent is found to be the effect of the residual antecedent. Direct experience plays a comparatively unimportant part while calculation or deduction figures largely. For this reason, **the Method of Residues has been regarded as essentially a Method of Deduction.**

It is a special modification of the Method of Difference

The Method of Residues may be regarded as a special modification of the Method of Difference, because, the principle underlying both these methods is the same, *viz*, if there are two instances, which differ only in one circumstance which is present in one instance, and absent in the other, then the circumstance, in which alone the two groups of antecedents differ, is the cause of the other circumstance in which alone the two groups of consequents differ. The difference between the two methods, however, is that in the Method of Difference, the instance in which the circumstance does not occur is supplied by Experiment, whereas in the Method of Residues, that instance is supplied by deduction from previous inductions. The Method of Difference is an inductive method *par excellence,* while the Method of Residues contains an element of Deduction.

Sec. 8. General Remarks about the "Methods."

A. INTER-RELATION OF THE FIVE EXPERIMENTAL METHODS

Mill's Five Methods:

Mill formulates *five** rules for causal investigation, which he respectively calls the Method of Agreement, the Method of Difference, the Joint Method of Agreement and Difference, the Method of Concomitant Variations, and the Method of Residues. Of the five Methods, the Methods of **Agreement and of Difference** are recognised by Mill as the two fundamental methods while the others are special forms of the Method of Agreement or of Difference or of both.

Agreement and *Difference* alone are fundamental; while

the Joint Method is a form of the Method of Agreement.

The **Joint Method**, for example, is not an independent method but is only a special modification of the Method of Agreement. The latter method is vitiated by the possibility of the Plurality of Causes and with a view to obviating this difficulty, the Joint Method is applied. The Joint Method is a double application of the Method of Agreement, inasmuch as, in it, we take two sets of instances, one showing agreement in presence and the other, agreement in absence. Hence the Joint Method has very aptly been called the Method of Double Agreement. The Joint Method, however, should not be confused with the Method of Difference.

The Method of Concomitant Varia-

The Method of **Concomitant Variations** may be regarded as a special modification of the Method of

* Mill speaks of "four" methods of Experimental Inquiry though he gives "five" canons, because the Joint Method is not reckoned by him separately.

Agreement, or of the Method of Difference, according to circumstances. *If the other conditions be the same,* it is a modification of the Method of Difference; *if the other conditions be different,* it is a modification of the Method of Agreement.

tions may be a form of *Agreement* or of *Difference*

The **Method of Residues**, as Mill conceives it, is "in truth a peculiar modification of the Method of Difference". The principle underlying them is the same, the only difference is in the way the negative instance is secured. In the Method of Difference, the negative instance, in which the phenomenon under investigation does not occur, is secured by experiment, while in the Method of Residues, the negative instance is obtained by deduction from previous inductions.

The Method of Residues is a form of the Method of Difference

Of the Methods of Agreement and of Difference, again, according to Mill, the Method of Difference is the more fundamental, because, while the Method of Agreement merely *suggests* a causal connection, the Method of Difference *proves* a causal connection

Mill says that *Difference* is more fundamental than *Agreement*.

According to **Carveth Read**, *the Method of Agreement can be reduced to the Method of Difference* "for the cogency of the Method of Agreement. .. .. depends upon the omission, in one instance after another, of all other circumstances, which omission is a point of difference" In the Method of Agreement, the instances *agree* only in one point and in all other points they differ. Hence it may be said that the Method of Agreement can be reduced to the Method of Difference, which accordingly is the most fundamental of all the methods.

Carveth Read says that *Agreement* can be reduced to *Difference*,

It should be pointed out that in one sense *the Method of Difference also may be considered reducible*

Some say *Difference* can be

reduced to *Agreement;* but

to the Method of Agreement. The Method of Difference requires that the two instances should differ only in one point, *while in all other respects they must agree.* Hence, the Method of Difference presupposes Agreement.

they are both equally fundamental

The fact is that Agreement and Difference are two aspects of the same thing. If two things agree in some respects, it necessarily implies that in other respects they differ. Agreement and Difference always go together and both of them are equally fundamental. It is futile to attempt to reduce the one to the other.

Hence we conclude that the Methods of Agreement and of Difference are the two fundamental methods, while the other three methods are their modifications.

B METHODS OF OBSERVATION AND METHODS OF EXPERIMENT

A division of the "Methods" into those of Observation exclusively and those of Experiment exclusively, is not possible

The question here is—Can we divide the Experimental Methods into those that exclusively employ Observation, and those that exclusively employ Experiment?

Such a division presupposes that there is a real opposition between Observation and Experiment, but as a matter of fact, far from there being any fundamental opposition between the two, Experiment is a species of Observation—Observation under known conditions Hence, we cannot divide the methods as methods of Observation exclusively, and methods of Experiment exclusively.

The **Method of Agreement** however is *essentially* a method of Observation, because the sort of instances which it requires can be supplied by Observation. If Observation can supply its instances, Experiment can certainly supply its instances. When however we say, it is essentially a method of Observation, we do not mean that it cannot obtain its materials from Experiment, but we mean that if we can employ experiment, we should take the help of other methods (such as the Method of Difference) which yield more conclusive results.

Agreement is essentially a method of Observation.

The **Method of Difference** is *essentially* a method of Experiment. This method can also be employed in simple Observation as in our everyday inferences. When however we derive our materials from simple Observation, the results are not conclusive. It is only Experiment which can furnish instances of the rigid and definite kind, necessary for the fulfilment of the strict requirements of the Method of Difference.

Difference is essentially a method of Experiment.

The **Joint Method,** being merely a double application of the Method of Agreement and not an independent method, stands on the same footing as the Method of Agreement.

The Joint Method is a method of Observation.

The **Method of Concomitant Variations** may be a modification of the Method of Agreement, or of the Method of Difference, according to circumstances. When it is a form of the Method of Agreement, it is essentially a method of Observation, when, on the other hand, it is a form of the Method of Difference, it is essentially a method of Experiment.

Concomitant Variations may be a Method of Observation or of Experiment.

The **Method of Residues** is a special modification of the Method of Difference, and as such, it may

The Method of Residues is essentially

a method of Experiment.

be said to be *essentially* a method of Experiment. It is also used in Observation but its conclusions can be certain only when Experiment is employed

C. METHODS OF DISCOVERY AND OF PROOF.

Agreement suggests causal connection and as such is a method of Discovery

According to Mill, the Experimental Methods are methods of Proof and not of Discovery. Mill, however, is not consistent in his views. So far as the **Method of Agreement** is concerned, he concludes that it *suggests* causal connection but *cannot prove it* The Method of Agreement suggests a cause, and the Method of Difference determines whether the supposed cause is the real cause. Hence, from this point of view, it may be said that the Method of Agreement is a method of Discovery rather than of Proof.

Difference proves causal connection and as such, is a method of Proof

So far as the **Method of Difference** is concerned, according to Mill, it is a method of Proof *par excellence*.

The Joint Method is more a method of Proof than one of Discovery

The **Joint Method** may be said to be more a method of Proof than one of Discovery. It is specially applied for obviating the difficulties arising out of the Plurality of Causes and frustrating the Method of Agreement. Hence it may be said to test the supposed cause suggested by the Method of Agreement by observing a set of negative instances.

Concomitant Variations helps discovery.

The **Method of Concomitant Variations** is very fruitful in Discovery. When two phenomena vary concomitantly, it at once suggests to our mind that there is some connection between them When it is a modification of the Method of Difference, this suggestion is proved to be true, but when it is a

modification of the Method of Agreement, the conclusion remains merely probable.

The **Method of Residues** is a special form of the Method of Difference but it is not only a method of Proof but also a method of Discovery. Some of the important discoveries in different sciences have been made by the application of this method. When we find that there is something unexplained in the phenomenon which is known in other ways, we try to find out the cause of the unexplained part of it. Hence the Method of Residues is a "finger-post to the unexplained". *Residues also helps discovery.*

Sec. 9. Criticism of the "Methods."

Mill makes very high claims for the Experimental Methods. According to him, they are "the only possible modes of experimental enquiry—of direct induction .. as distinguished from deduction". He further says: "The business of Inductive Logic is to provide rules and models to which if inductive arguments conform, those arguments are conclusive, and not otherwise. This is what the. . methods profess to be". Mill makes high claims for the "Methods"; but

These claims are not universally granted by Logicians and we may summarise the objections against the Methods under *three* main heads: *viz.*, (1) *Firstly,* the Methods take for granted that the complex phenomena of Nature are reducible into simple formulae · (2) *Secondly,* the Methods are frustrated by Plurality of Causes and Intermixture of Effects; and (3) *Lastly,* the Methods are not inductive at all but are at bottom really deductive in character. Let us deal with each of these objections at some length. they are open to three main objections —

1 The Methods presuppose that the phenomena of Nature are simple whereas they are really highly complex

1. The Methods presuppose that the complex phenomena of Nature are reducible to simple formulae.

The Methods suppose that in Nature phenomena are presented in a state of such simplicity that they can be represented by simple formulae The Methods proceed on the assumption that we have a number of antecedents all clearly determined, and a number of consequents of a similar character. As a matter of fact, however, natural phenomena are so complex that the representation of the antecedents by A, B, C, etc., and of the consequents by a, b, c, etc., is quite deceptive. The employment of the capital and small letters would seem to indicate that we can detect at once which fact is antecedent and which fact is consequent. But frequently this is not the case. Hence, **Whewell** complains that the "Methods" take for granted the very thing which it is most difficult to discover, *viz.*, reduction of the complex phenomena of Nature to simple formulae.

Mill answers this objection by admitting that it is difficult to obtain premises of Induction and to reduce them to simple forms. But before trying to reduce a complex phenomenon found in Nature to simple forms, it is necessary to know the form to which the facts are to be reduced. Just as in Deduction, we have the syllogism to which all deductive arguments conform, so in Induction, we have the "Methods" to which all inductive arguments must conform in order that they may be valid

2 Plurality of Causes and Intermixture of

2. Plurality of Causes and Intermixture of Effects frustrate the Experimental Methods

The Inductive Methods suppose two things, *viz.*,

(*i*) an effect has only one cause, or set of antecedents; and (*ii*) different effects are kept apart and are distinguishable. But both these suppositions are unwarranted.

Effects constitute a bar to the "Methods."

'Plurality of Causes' states that the same effect may be due to different causes on different occasions. This frustrates the Method of Agreement. The multiplication of instances and the application of the Joint Method may considerably reduce chances of the failure of the Method of Agreement but the possibility of error does not disappear altogether. Even the Method of Difference can only prove that in the given case, a particular circumstance is the cause. But it cannot prove that it is the cause in all cases. As the other Methods are modifications either of *Agreement*, or of *Difference* they also are more or less liable to frustration by the Plurality of Causes.

According to 'Intermixture of Effects,' the effects of different causes may not be distinguishable, and a single phenomenon may be the result of causes operating jointly. For example, a good crop is a single fact which is the joint effect of several agencies, *e.g.*, the nature of the soil, sufficient rain, labour of the cultivator and so on. The Experimental Methods require that separate effects should be distinguishable in the form A B C.........a b c; hence, if the various effects are mixed together, it is impossible to determine to which antecedent, any one of the intermixed effects is due, and therefore, the Methods become inapplicable to such cases.

In cases of Intermixture of Effects, the Methods of Concomitant Variations and of Residues are of some help. If two phenomena vary concomitantly,

The Methods of Concomitant Varia-

tions and Residues are useful to combat Intermixture of Effects

The best method to combat Intermixture of Effects is the Deductive Method, which is a combination of Induction and Deduction.

there is a strong suspicion that they are causally connected and that suspicion may prove the starting-point of fruitful results. The Method of Residues also is of some help, for, when we notice some unexplained residue in a complex effect, we are led to suppose an additional cause for such residue, and we conduct further investigations in that direction.

It may be pointed out, however, that the Experimental Methods cannot completely overcome the difficulties arising out of the Plurality of Causes and the Intermixture of Effects In order to cope with these difficulties successfully, it is necessary to employ what is called the **Deductive Method,** which is a combination of Induction and Deduction.

3. The so-called Inductive Methods are really deductive in character.

3 Formal character of the Experimental Methods

The most serious objection against the Experimental Methods is that far from being "inductive methods", in which we proceed from the particular to the general, they are really deductive in character, proceeding from a general principle to a particular application of it As **Bain** puts it[1] "These are called by courtesy Inductive Methods; they are more properly Deductive Methods, available in Inductive investigations" The truth of this remark would be quite clear when we fully understand the process of reasoning involved in the Methods

Agreement

The **Method of Agreement** is based on the principle "Whatever can be left out without prejudice to the effect can be no part of the cause" This principle is deduced from the Law of Causation. (See Sec. 2 of this Chapter—p. 159). Taking this principle as the major premise, let us have the following syllogism :—

Whatever can be left out is not the cause
B, C, D, E, can be left out
∴B, C, D or E is not the cause

But the Law of Causation states that every event has a cause. Therefore, the Method of Agreement concludes that the invariable antecedent, *A* is the cause of the invariable consequent, *a*

Thus, the Method of Agreement is a deduction from the Law of Causation, and the principle of Elimination deduced from the Law of Causation.

Difference

So also with the **Method of Difference.** The Method of Difference is based on the principle: "Whatever cannot be left out without affecting the effect is the cause". Taking this to be the major premise, let us have the following syllogism:

Whatever cannot be left out is the cause
A cannot be left out
∴ A is the cause

Thus we find that the Method of Difference is a deduction from the principle stated above, which again is deduced from the Law of Causation.

Concomitant Variations.

Similarly, it can be shown that the **Method of Concomitant Variations** is a deduction from the principle: "An antecedent and a consequent rising and falling together in numerical concomitance are held to be cause and effect".

Joint Method.

So far as the **Joint Method** is concerned, as it is a modification of the Method of Agreement, it stands on the same footing as the latter method in this respect.

Method of Residues.

As for the **Method of Residues,** Mill himself admits that there is an element of deduction in it, inasmuch as the negative instance, showing the absence of the phenomenon under investigation, is

secured not by Observation or Experiment, but by Deduction from previous knowledge. It is quite clear that being a special form of the Method of Difference it stands on the same footing as the latter in this respect.

Conclusion. Hence we conclude that *the so-called Inductive Methods are not inductive at all but are purely deductive in character.* They are deductions from the Law of Causation. As **Carveth Read** says: "Inductive Logic may be considered as having a purely formal character. It consists (1) in a statement of the Law of Cause and Effect; (2) in certain immediate inferences from this Law, expanded into the Canons; (3) in the syllogistic applications of the Canons to special propositions of causation by means of minor premises, showing that certain instances satisfy the Canons".

TYPICAL EXERCISES WORKED OUT.

Q. Name the Experimental Method by which each of the conclusions is proved, explaining its applicability in each case :—

[GENERAL HINTS: In answering questions of this description, the student will do well to remember the special characteristics of the different Methods. The Method of *Agreement* requires several instances, at least two, which agree in the presence of some circumstance; the *Joint Method* requires two sets of instances, each containing several instances, at least two; and some circumstance is uniformly present in the positive set and uniformly absent in the negative set; the Method of *Difference* requires only two instances, which differ only in one circumstance, other circumstances being exactly the same; the Method of *Concomitant Variations* is employed when a particular circumstance varies along with the phenomenon under investigation; and lastly, the Method of *Residues* is employed when there is some previous knowledge of causation. Sometimes because of the very meagre materials given in these questions, it may be found that more than one method may be made applicable In such cases, it will be sufficient for the student to show that one particular method has been employed but it is absolutely necessary that he should give reasons why he thinks so.]

(1) *Scarlet flowers have no fragrance.*

Answer:—This conclusion has been arrived at by the application of the Method of Agreement.

We examine several kinds of scarlet flowers and find that they all agree in this that they have no fragrance. Scarlet colour and absence of fragrance are uniformly present together in several instances, and hence according to the Method of Agreement they are causally connected.

This conclusion is merely probable and not absolutely certain because, the Method of Agreement cannot conclusively prove causation.

(2) *If a particular portion of the brain is removed, a particular part of the body is paralysed.*

Answer:—This conclusion has been arrived at by the application of the Method of Difference.

We take two instances only. In one instance, the entire brain is there and all parts of the body are working normally. In the other instance, which is obtained by experiment, we remove a particular portion of the brain and find that while other circumstances remain exactly the same, a particular part of the body is paralysed. Hence we conclude that the removal of a particular portion of the brain is the cause of the paralysis of a particular part of the body.

The conclusion is certain, because, in this case the instances required for the application of the Method of Difference have been supplied by experiment. As in experiment we can control the surrounding circumstances, we are positive that the instances differ only in one respect and other circumstances are exactly the same.

(3) *The increase in the number of crimes in a village is due to the removal of the police station.*

Answer:—This conclusion has been arrived at by the application of the Method of Difference

We argue in this way The police station is there and there are a few cases of crimes. The police station is removed and crimes increase Hence according to the Method of Difference, we seek to arrive at the conclusion that the removal of the police station is the cause of the increase of crimes.

In this illustration the instances are supplied by Observation and not by Experiment and hence we cannot be certain that other circumstances are exactly the same, and that the removal of the police station is the only change introduced in the antecedent. Hence the conclusion is not certain.

(4) *The appearance of the comet is the cause of the death of the king*

Answer:—This is a fallacious application of the Method of Difference

It is argued that something is introduced and something happens The comet appears and the king dies. But besides the appearance of the comet, there were various other antecedents; and again, besides the death of the king, there were various other consequents It is not at all true that the only change in the antecedents is the appearance of the comet and the only change in the consequents is the death of the king Hence the necessary conditions of the application of the Method of Difference are wanting

In fact this argument illustrates the fallacy of *Post hoc ergo propter hoc*, according to which any and every antecedent is mistaken for the cause while the real cause must be an invariable and unconditional antecedent

(5) *Intermittent fever is found only in places where there are marshes, even though they differ in every other respect*

Answer·—This conclusion is arrived at by the application of the Joint Method

There are two sets of instances In the positive set, we examine several instances and find that where there are marshes, there is intermittent fever; we then take a set of negative instances and find that where there are no marshes, there is no intermittent fever From this we conclude by the application of the Joint Method that marshes are the cause of intermittent fever

The conclusions arrived at by the application of the Joint Method are more probable than those which are arrived at by the application of the Method of Agreement. Hence the given conclusion may be said to be highly probable but not certain.

(6) *A nation becomes more and more prosperous as it develops in an increasing measure habits of industry and prudence*

Answer·—This conclusion has been arrived at by the application of the Method of Concomitant Variations.

We observe several instances and find that as habits of industry and prudence develop more and more, a nation becomes more and more prosperous Thus industry and prudence, on the one hand, and prosperity of a nation, on the other hand, vary together Hence according to the Method of Concomitant Variations, industry and prudence are the causes of the prosperity of a nation

In this illustration the instances for the application of the Method of Concomitant Variations have been supplied by Observation and not by Experiment, and as such the conclusion is not so certain as it would have been in the latter case

(7) *Heat is the cause of the melting of ice.*

Answer·—This conclusion may be arrived at by the application of different Methods but the nature of the

materials or premises from which the conclusion is drawn would be different in different cases.

Suppose we examine several instances and find that in all of them, heat is present and ice melts According to the *Method of Agreement* we can arrive at the conclusion that heat is the cause of the melting of ice.

Suppose again we make an experiment. We take a lump of ice and apply heat to it. We find that ice melts. According to the *Method of Difference*, we can conclude that the application of heat is the cause of the melting of ice.

Suppose again we find that the greater the heat, the more quickly does ice melt In other words, the degree of heat and the rate at which ice melts vary concomitantly. Hence according to the *Method of Concomitant Variations*, we can conclude that heat causes the melting of ice.

Lastly, this may be an illustration of the *Joint Method* in the following circumstances Suppose we observe two sets of instances In the positive set of instances, heat is uniformly present and melting of ice is uniformly present; in the negative set, both are uniformly absent. From this, according to the *Joint Method* we conclude that heat is the cause of the melting of ice.

Though as shown above, this argument may be used for the illustration of the Methods of Agreement, Difference, Concomitant Variations, the Joint Method alternatively, the most satisfactory view is that here the Method of Concomitant Variations has been employed, because *heat* is a phenomenon which cannot be wholly eliminated It may be mentioned that in cases where several answers are possible, the student may give only one, provided he gives his reasons.

(8) *Two small pieces of blanket, exactly alike in all respects except that one is coloured white and the other black, are placed on a block of ice. After a certain time it is found that the black piece has sunk deeper into the ice than the white one Therefore, it is concluded that black absorbs more heat than white*

Answer:—This argument is based on the Method of Difference We take two instances and two instances only In one instance, a white piece of blanket is placed on a block of ice and it does not sink deep enough; and in the other instance, a black piece of blanket is placed on a block of ice and it sinks deeper than the white one Everything else is exactly the same Hence according to the Method of Difference we conclude that black absorbs more heat than white As the instances are obtained by Experiment, we are certain that the strict requirements of the Method of Difference have been complied with, and the conclusion is certain

(9) *A large number of birds has been examined and found to be without teeth. Therefore, it is inferred that all birds are without teeth.*

Answer:—This argument is based on the Method of Agreement. We examine several birds and observe that they are without teeth. In other words, the several birds examined agree in not having teeth. From this we conclude according to the Method of Agreement that there is a causal connection between the nature of birds and absence of teeth. As the Method of Agreement cannot distinguish causation from co-existence, we cannot be certain as to whether there is a relation of co-existence or one of causation between these two phenomena.

(10) *One Sunday morning in a poor country parish there appears the surprising phenomenon of a half-sovereign in the offertory; the clergyman knows by repeated experience that none of his flock ever by any chance gives more than a silver three-penny piece; but he has perceived a stranger in the congregation, and, therefore, he concludes that the stranger is the donor of the half-sovereign*

Answer:—This argument is based on the Method of Residues. The clergyman finds various small coins and a half-sovereign. From previous knowledge he knows that none of his flock would give a half-sovereign. Therefore, this residual phenomenon must have a cause The half-sovereign must have been given by some one other than members of his flock and when the clergyman finds that there was a stranger, he concludes that the stranger must have given the half-sovereign. As the instances have been obtained by Observation, the conclusion is probable and not certain.

(11) *Despotic government gradually disappears as the people are more and more educated*

Answer —This argument is based on the Method of Concomitant Variations We find that two phenomena, *viz*, education and despotic government vary together; as education increases, despotic government gradually decreases. From this we conclude that they are causally connected. This is an instance in which the Method of Concomitant Variations is a modification of the Method of Agreement and as such the conclusion is probable but not certain.

(12) *Able men have generally very bad handwriting while good handwriting is frequently found in men doing comparatively little mental work Hence it is inferred that mental strain is the cause of poor penmanship.*

Answer —This argument may be analysed as follows: We examine several instances and find that where there is ability, there is bad handwriting, this is the set of positive instances. We examine several other instances and find that ability is wanting and bad handwriting is also wanting; this is the set of negative instances From this according to the

Joint Method we conclude that ability is the cause of bad handwriting. The Joint Method though superior to the Method of Agreement is still a method of Observation and as such is subject to all the limitations to which observation is subject Hence the conclusion cannot be called certain.

(13) *Mosquitoes cause malaria, because both mosquitoes and cases of malarial fever have become much rarer in parts of Italy, and West Africa and elsewhere after these districts were well drained.*

Answer·—It is observed in several instances that drainage is bad, and mosquitoes and malarial fever are present. Drainage is improved, mosquitoes and malarial fever become rarer. From this it may be concluded that bad drainage is the cause of mosquitoes and malarial fever, by the application of the Method of Concomitant Variations. The conclusion actually drawn however is, Mosquitoes are the cause of malarial fever, whereas the proper conclusion warranted by the premises is that mosquitoes and malarial fever are co-effects of the same cause, *viz*, bad drainage.

(14) *Scarlet poppies, scarlet verbanas, the scarlet hawthorn and honey-suckle are all odourless, therefore we may conclude that all scarlet flowers are destitute of odour.*

[HINTS This is an inductive argument based on the Method of Agreement We observe several kinds of scarlet flowers and find that they agree in being odourless. From this we conclude that there is a causal connection between the scarlet colour in flowers and odourlessness. As the Method of Agreement is based on Observation, it cannot distinguish causation from co-existence It may be that the scarlet colour and absence of odour are co-effects of the same cause. Hence at best the conclusion can be said to be probable and not certain See p 203, Exercise (1)].

(15) *It has been held that linnets when shut up and educated with singing larks—the skylark, woodlark or titlark will adhere entirely to the songs of these larks, instead of the natural song of the linnets. We may infer therefore that birds learn to sing by imitation and their songs are no more innate than language in man.*

[HINTS· This argument is based on the Method of Difference. Linnets sing naturally in a particular manner. Then some linnets are shut up and educated with singing larks and the effect is that these linnets imitate the song of the singing larks In this case, a new factor is introduced and something new happens If we make sure that everything else is the same, the conclusion is certain]

(16) *Vesalius, the founder of modern anatomy, found that the human thigh bone was straight, and not curved, as Galen, the great authority on the subject for over a thousand years, had asserted Sylvius replied that Galen must be right; that the bone was curved in its natural condition,*

but that the narrow trousers worn at the time had made it artificially straight

[HINTS The argument of Sylvius may be said to be based on the Method of Difference Suppose the thigh bone is naturally curved Narrow trousers are worn and the thigh bone becomes straight The introduction of a new factor is followed by the change and therefore must be the cause of the change Now this argument takes for granted two things without any justification, *viz*, that as a matter of fact the thigh bone was curved at the time of Galen, and further that during the interval between the period of Galen and that of Vesalius, there was no other change introduced except the wearing of narrow trousers Hence the argument has no value whatsoever In the Method of Difference the instances must be secured by Experiment and we must be certain that they differ only in one respect while in other respects, they are exactly the same As these conditions have not been fulfilled in this case, the argument is worthless]

(17) *States that have grown outrageously luxurious have declined in power Hence we conclude that luxury was the cause of their downfall.*

[HINTS We observe several instances in which states were outrageously luxurious and there was decline of power. According to the Method of Agreement, we conclude that luxury is the cause of the downfall This conclusion however is merely probable Extreme luxury at the worst may be one of the many conditions of the downfall but it cannot be regarded as the sole cause Hence this argument may be said to illustrate the fallacy of mistaking a condition for the whole cause 'Luxury' and 'Decline in power' may also be co-effects of a common cause *e g*, institution of slavery, the corruption of officials, an army too powerful for discipline]

(18) *The eating of mangoes is the cause of boils*

[HINTS This argument is based on the Method of Agreement We want to find out the cause of boil We collect by means of observation several instances of persons suffering from boils and find that one circumstance common to all these instances is 'the eating of mangoes', while other circumstances are different From this we conclude that there is a causal connection between "the eating of mangoes" and 'boils' As the argument is based on the Method of Agreement the conclusion is merely probable and not certain]

(19) *The mind must be a function of the brain since any serious injury to the brain is always followed by loss of consciousness*

[HINTS · This argument is based on the Method of Agreement We collect by means of observation several instances in which we find that while in the antecedents there

is serious injury to the brain, there is always loss of consciousness in the consequents. From this invariable and uniform sequence we conclude that serious injury to the brain is the cause and loss of consciousness is the effect. As the argument is based on the Method of Agreement the conclusion is not certain. It should be pointed out here that consciousness and the brain are absolutely different and as such one cannot be the cause of the other.]

(20) *A conjuror produces wonderful results by different tricks on different occasions, taking care to wave his hand each time. Therefore the waving of the hand is the cause of the wonderful results.*

[HINTS. This argument illustrates how the possibility of a plurality of causes frustrates the Method of Agreement. We observe several cases and find that a conjuror performs different tricks and on every such occasion there is waving of the hand From this we conclude that the waving of the hand is the cause, and the tricks are the effects. As a matter of fact however the waving of the hand is an irrelevant antecedent and the real cause is different in different cases.]

EXERCISE V.

1. What do you understand by the Experimental Methods? Why are they so-called?

2. Why is it thought necessary to deal with the Methods of Experiment in Logic?

3A. Discuss the question whether the Inductive Methods may be viewed as mere weapons of Elimination.

3B. "To vary the circumstances is the fundamental principle upon which the Experimental Methods are based". Explain.

4. What are the two main principles involved in Mill's Canons of the Experimental Methods?

5 What are the various Canons of Elimination? Show by concrete examples how each of them furnishes a method of enquiry into causation

6 Enunciate and explain the canons or principles which underlie the Experimental Methods. Give concrete illustrations.

7 State the Principles of Elimination and explain their relation to the Experimental Methods.

8. Explain and illustrate the Method of Agreement. Give symbolical and real examples of it How is the Method frustrated? Give an example. What is the remedy?

9 Explain and illustrate by a concrete example the Method of Agreement. Point out the difficulties connected with the employment of this Method.

10 Enunciate the Method of Agreement, pointing out its advantages and disadvantages. How are the disadvantages remedied?

11. Explain how Plurality of Causes and Intermixture of Effects affect the application of the Method of Agreement What advantage has the Method of Difference over the Method of Agreement and what advantage has the latter over the former?

12. State the Canon of the Method of Agreement and illustrate its use by a concrete example. When is it necessary to use the Joint Method of Agreement and Difference? Illustrate it by a concrete example.

13 "The Method of Agreement is essentially a Method of observation the Method of Difference, of experiment." Discuss and illustrate.

14. 'The Method of Agreement is a method of Discovery. The Method of Difference is a method of Proof.' Explain the significance of this remark.

14A. "The chief use of the method of Agreement, is to suggest hypotheses as to the cause" Explain with examples.

15 Explain why it is necessary to employ the Joint Method of Agreement and Difference State and illustrate this Method by a concrete example.

16 State and explain the Canon of the Joint Method (the Double Method of Agreement), illustrating it by a concrete example What is the special advantage of this method?

17 Give a brief account of the Joint Method of Agreement and Difference, and with the help of instances show what are its advantages and disadvantages as a scientific method.

18. State in your own words and illustrate with examples (symbolical and real) the Method of Difference Show by common instances that the Method plays a great part in everyday inferences.

19 Explain the Method of Difference Do you think that the conditions which the Method of Difference requires can be fulfilled in any situation in our experience?

20 Explain and illustrate the Method of Difference, showing its close connection with experiment and practical life Point out how a careless use of it leads to the fallacy of *post hoc, ergo propter hoc.*

21. Explain, giving a concrete example, the Method of Difference and point out its relation to the Methods of Concomitant Variations and Residues Explain the nature of phenomena for the investigation of which the last two methods are particularly suited

22 The Method of Difference is claimed to be in the nature of an experiment Why? Give examples

23 State and illustrate the canon of the Method of Difference Why is this method applicable only to the spheres where experiments can be employed?

24 Discuss the principle underlying the Method of Difference Give a concrete example. Show how far multi-

plicity of instances increases the probability of induction, so far as the Method of Agreement is concerned.

25. State fully and clearly in your own words the Method of Concomitant Variations with examples On what canon or principle is it based? Of what other Method is it a modification? Is it a method of Observation or of Experiment or of both? In what class of cases is it the only possible inductive method, and why?

26 Explain and illustrate the Method of Concomitant Variations What are the circumstances under which it is specially applicable?

27 When is it necessary to employ the Method of Concomitant Variations? Explain and illustrate this Method, indicating its different forms.

28 Give a concrete example of the Method of Concomitant Variations Indicate the limitation of this Method Explain the principle of the quantitative equivalence of cause and effect.

29 'The Method of Concomitant Variations and the Method of Residues are modifications of the Method of Difference.' Explain and illustrate this statement and indicate the cases in which each of these methods is appropriately employed.

30 Explain with examples the method of Concomitant Variations, and its relaion to the method of Difference

31. State the Method of Residues fully with examples, symbolical and concrete. Does it involve any element of Deduction? Show how it may lead to the discovery of new antecedents Give some examples of this

32 Can we regard the Method of Residues as a distinct Method of Induction?

33. Show, by an example, that the Method of Residues involves the application of Deduction

34. Explain the nature and the utility of the Method of Residues and illustrate your answer by a concrete example.

35 What are the two ways in which the Method of Residues may be applied?

36 Show in what respects the Method of Difference (a) agrees with, and (b) differs from, the Method of Residues Illustrate the working of the latter in Natural Science

37 The Method of Concomitant Variations is only a modification of the Method of Agreement Explain critically the truth of this statement, illustrating your answers with examples

38 "Mill has formulated, not five Inductive Methods but one Method of Experimental enquiry" Discuss. How are Mill's Inductive Methods inter-related?

39 Can Inductive Methods be correctly divided into methods *either* of Observation and methods of Explanation *or* into these and Experimental Methods?

40 Show that the so-called Inductive Methods are really deductive in character.

41. Discuss the part played by deductive inference in inductive enquiry.

42. Show how Intermixture of Effects prevents the employment of the Experimental Methods. Do all the Experimental Methods fail in such a case? Give reasons for your answer.

43. How do Plurality of Causes and Intermixture of Effects tend to frustrate the application of the Experimental Methods? And what are the remedies by which the difficulties created by them are overcome?

44. Explain and illustrate the chief difficulties which tend to frustrate the Experimental Methods, indicating clearly the ways in which they are overcome.

45. Explain and illustrate—Negative instance What is the importance of the negative instance in inductive reasoning?

46. Show by examples how experiments help to prove causation

47 Attempt a critical estimate of the use and importance of the Inductive Methods.

48 Construct an inductive argument to prove that some article of food or some habit is beneficial or injurious to you; and analyse your reasoning showing the method or methods employed by you.

EXERCISES FOR ADVANCED STUDENTS

1. What is the distinction between Induction by Simple Enumeration and Induction through the Method of Agreement? On what presupposition is the former method applicable? What are its defects and its utility in scientific discovery?

2. Explain the Method of Concomitant Variations. Give examples of cases where its application is extremely profitable, and point out the limitations attending its use.

3 Analyse and describe in logical terms the method by which any important discovery of recent years was made.

4 How far does the validity of any of the Inductive Methods depend on the possibility of expressing cause and effect quantitatively?

5 Explain why the Method of Agreement requires many instances, while the Method of Difference is satisfied with one precise experiment.

6 Can the Method of Residues be fairly considered inductive in character?

7 What does Mill mean by Cause? How far are his methods adequate for the discovery of causes in his own sense of the word?

8 State the Experimental Methods, and deduce them from the ultimate postulate of Inductive Logic.

9. State the canons of the method of agreement and difference, and point out the precise function of these methods in scientific research.

10 Discuss the logical value of Mill's Methods of Agreement, considering more particularly whether his symbolic representation conforms to the actual process of scientific discovery.

11. How far have the Experimental methods assisted the discovery of the laws of Nature? Give illustrations in support of your statements.

12 What are the more important objections brought against the methods of Induction formulated by Mill? Give your view of the value of these methods

13. Discuss whether or how far, the five Experimental Methods are workable in the case of Plurality of Causes.

14 Can the Methods of Induction be reduced to one Method? Are they logically valid?

15. Explain the following, giving explanation of the terms involved in it "There is one fundamental mode of Proof—Agreement through all nature—by which all ultimate laws are established including causation. There are several derivative, deductive or dependent methods of Proof, the special Methods of Elimination—Agreement, Difference, Variations; they are called by courtesy Inductive Methods; they are more properly Deductive Methods available in Inductive investigations"

16 If ABC have been followed by xyz, and BC by yz, are we entitled to the conclusion that A is the cause of x? Answer fully.

17 Exemplify the Method of Induction in a case in which a hypothesis is established by observation.

18 What is meant by saying that the cause of an effect can only be proved by a process of elimination? Do you consider that such a process is involved in Mill's Methods of Induction?

19. Does any importance attach to the number of instances examined? If so, for what reason?

20 How are experimental methods related to Inductive Reasoning?

21 "Some inductive methods are adapted for *suggesting* causes, others for *testing* them." Discuss

22 In arguing from effect to cause what methods are available? Is it always possible to trace back a given effect to one cause?

23. Explain the principle on which the Method of Residues proceeds, and illustrate its importance in the history of science.

24 Show by means of instances how the Method of Concomitant Variations is a peculiar application, or a series of applications, of the Method of Difference.

25. Explain and illustrate the principle of the method

by which quantitative relations are established between a cause and its effect.

26. Explain the working of the Method of Residues and illustrate its importance for Natural Science.

27 Are the canons of inductive reasoning themselves the result of observation?

28 Bring out the importance of the negative instance in the experimental methods and point out under what circumstances it ceases to be available.

29. 'Mill's Inductive Methods are all reducible to one principle—the elimination of the inessential' Explain and discuss.

30 State the difficulties in the way of proving the following propositions, and indicate any method of investigation applicable to the case of each:—

(1) The carriage was not torn till after the front wheels came off.

(2) Koch's fluid is a cure for consumption.

(3) The death of the trees planted in the streets is due to gas poisoning

31 By what methods do you investigate the cause of the following phenomena?

(*a*) The rise and fall of the mercury in a thermometer.

(*b*) The habit of saving.

32 Supposing us to be unacquainted with the causes of the following phenomena, by what methods should we investigate each?

(*a*) The connection between the barometer and the weather

(*b*) A person poisoned at a meal.

(*c*) The connection between the hands of a clock

(*d*) The effect of the Gulf-stream upon the climate of Great Britain.

33. Explain fully what logical methods would be of greatest value in determining: (*a*) the cause of a plague, (*b*) the date of the next eclipse of the sun; (*c*) the effects of the retail sale of intoxicating liquors; (*d*) the prosperity or decline of a Public School; (*e*) an outbreak of cholera; (*f*) the explosion of a powder magazine; (*g*) thunderstorms are more frequent in the hilly than in the flat countries of England; (*h*) that colds are contagious is shown by the fact that whenever, a ship arrives at the island of St. Kilda, the islanders catch cold.

34 Test the following:—

(i) The excision of the thyroid glands dulls the intellect; hence the thyroid gland is the cause of our intelligence. [HINTS: Method of Difference; argument probable because applied in Observation, not Experiment].

(ii) As the fury of the storm increased, the pilot increased the speed of the plane; hence the storm is the cause of the aeroplane's speed. [*Post hoc ergo propter hoc.*]

35 It was long ago discovered that epidemics of small-pox could be prevented by isolating the earliest cases. What was the idea that promoted this measure? (Was it a hypothesis of Law or of Cause?) What method was revealed in the verification?

36 If to a set of circumstances in which A is known to be the sole cause of a and B the sole cause of b, there is added a new antecedent, C, does Mill's statement of Difference lead us to infer that the new consequent, c, is the sole effect of C?

37. Show that the specific problem of induction really begins where the method of Residues leaves off.

38. By what method would you verify the laws:—
"The shorter the pendulum, the faster it swings"?

39. It is said that light as a general rule retards the growth of plants. By what method was this law established?

40. It was an old belief that decaying matter such as meat generated flies. Can you think of the way in which the belief was disproved?

41. If the effects of ABCD are fully expressed by abcd, and those of BCD by bcd, what inductive inference can be drawn and on what principle? State the canon according to which it is drawn.

42. Compare the Canons of Agreement and of Difference (1) as to the difficulty of finding or preparing actual instances for them and (2) as to their conclusiveness.

43. What are the two main principles upon which the canons proposed by Mill are founded?

44. 'I have noticed that A always precedes B; it is therefore the cause of B' Is this good reasoning?

45. What precisely would be necessary to establish in order to prove inductively that some change in the tariff laws was beneficial to the country?

46. Explain what qualifications it is necessary to introduce in interpreting Mill's statement of the Joint method.

47. Give some instances of simple experiments fulfilling completely the conditions of the Method of Single Difference.

48 In a certain case of right-side paralysis a post-mortem revealed a blood-clot located in the left cerebral hemisphere. What statement could be made with regard to these facts? Would such a statement be the direct product of induction or deduction?

49. A man having been shot through the heart immediately falls dead. Investigate the logical value of such a fact as proving that all men shot through the heart will fall dead.

50 The murder of Archduke Ferdinand led to World War I.

CHAPTER VI.

INFERENCE FROM ANALOGY.

Sec. 1. Introductory.

Inductions proper may be divided into (i) Scientific Induction; (ii) Induction per Simple Enumeration; and (iii) Analogy We have dealt with Induction per Simple Enumeration in Ch I, Sec 5B. So far as Scientific Induction is concerned, we have examined its method, its formal and material grounds, and the Experimental Methods, which aim at the discovery and proof of a causal connection, on which Scientific Induction is based. In this chapter, we shall proceed to examine the nature and conditions of the third form of Induction proper, *viz*, Analogy, and show that this is a weak form of inductive argument.

Sec. 2 Various meanings of 'Analogy.'

The word, Analogy, has been loosely used in a variety of senses The original Greek word *'Analogia'* was employed by **Aristotle** to signify an equality of ratios, corresponding to the word 'Proportion' in Arithmetic Thus according to Aristotle an inference from Analogy is of the following character:—

Aristotle.

$$1 : 2 :: 2 : 4$$

That is, one compared with two is *analogous to* two compared with four.

From proportion of numbers, we pass to *other proportions* in which the terms are not of the same kind. For example:—

Health : The Body :: Virtue : The Soul.

As Health is to the Body, so is Virtue to the Soul. That is the relation between 'health' and the 'body' is *analogous to* the relation between 'virtue' and the 'soul'.

Whately. In conformity with this original mathematical acceptation of the term, **Whately** defines Analogy as "RESEMBLANCE OF RELATIONS." For example, when a country which has sent out colonies is termed the mother country, the expression is analogical, signifying that the colonies of a country stand in the same *relation* to her in which children stand to their parents If from this resemblance of relation, we draw the inference 'Obedience is due from the colonies to the mother country', it would be an argument from Analogy This form of argument has been called by some Logicians "*Analogy of Relations*" and may be illustrated further as follows:—

Examples.

A is related to B as C is related to D

From the relation of A to B, x follows

Therefore, from the relation of C to D, x follows.

Concrete Examples:—

(1) The relation of the captain of a ship to the ship is analogous to the relation of a governor to the state· the captain guides the course of the ship, therefore, the governor should guide the destiny of the state.

(2) The relation of Parliament to the nation is like that of a board of directors to a joint-stock company; a joint-stock company is best managed by an elected board of directors; therefore, the affairs of a nation will be best managed by an elected Parliament The basis of this argument is not that a nation is like a joint-stock company or that Parliament is like a board of directors but that the *relation* between Parliament and the nation is the same as the *relation* between a board of directors and a joint-stock company.

Modern Logicians

According to the modern use of the word in Logic, however, 'Analogy' means more than a resemblance of relations. As **Mill** says· "It is on the whole more usual to extend the name of analogical evidence to *arguments from any sort of resemblance, provided they do not amount to a complete induction;* without peculiarly distinguishing resemblance of relation". In this, Mill adopts the previous usage of **Butler** and **Kant** and it is in this sense that the term is used at

the present day by Logicians. It may be noted that what modern Logicians call 'Analogy' was designated by **Aristotle** as **Paradeigma** or **Argument from Example.** As an illustration, Aristotle gives the following. Athletes are not chosen by lot, therefore neither should statesmen be. We shall now proceed to determine the nature of the Analogical Argument understood in this sense.

Sec. 3. Nature of Argument from Analogy

Definition. Mill.

According to **Mill,** Analogical reasoning may be reduced to the following formula: "Two things resemble each other in one or more respects; a certain proposition is true of the one, therefore it is true of the other". **Bain** defines it as follows: "Analogy...... ....as a distinct form of inference, supposes that two things from resembling in a number of points, may resemble in some other point, which other point is not known to be connected with the agreeing points by a law of causation or of co-existence". **Carveth Read** defines Analogy as **"a kind of probable proof based on imperfect similarity......between the data of comparison and the subject of our inference."** **Welton** regards Analogy as "an inference from partial identity of content to further identity of content". Thus Analogy is a kind of inference from particular to particular, based on imperfect similarity and is only probable in character. To take a **symbolical example**:

Bain.

Carveth Read.

Welton.

Symbolical example.

A resembles B in certain properties, *viz*, x, y and z.
B further possesses the property m.
∴ A posesses the property m, even though no connection is known to exist between m and the common properties x, y and z.

As a **concrete example,** the following argument

which astronomers offer for the presence of life on the planet Mars has been generally adopted by Logicians:— Concrete example.

Mars resembles the Earth in certain respects, *viz*, in being a planet, possessing similar atmosphere, land, seas, polar regions, temperature, (neither too hot nor too cold for life) revolving round the sun and borrowing light from the sun, etc.

The Earth possesses the further property of being inhabited.

∴ Mars possesses the property of being inhabited.

Resemblance is the Ground of all inference.

Analogy compared with Induction and

The ground of inference in Analogy is *resemblance*. We argue that two things alike in some respects are also alike in some other property—that A resembles B in some properties, and therefore, also in some other property. But this is not a peculiar characteristic of analogical reasoning. **In Induction* as well as in Deduction, we similarly argue on the basis of resemblance.** In INDUCTION, for example, we argue:—

A, B, C, D, etc., men who have been examined, are mortal.

∴ All men (examined and unexamined) *resembling*, as they do, A, B, C, D who have been examined, *in being men*, will further resemble them *in being mortal.*

The difference between an Induction and an Analogy, however, is that in Induction, a causal connection is known to exist between the common properties and the inferred property, whereas, in Analogy, such a knowledge is wanting. When, for instance, we infer that Mars is inhabited, on the analogy of the presence of life on the Earth. we are not aware that there is any necessary causal connection between the properties common to Mars and the Earth, and the

* The word 'Induction' has been used here in a restricted sense to exclude Analogy.

presence of life If such a connection had been known to exist or if such a connection is established at some future time, the argument would no longer be merely analogical but would be elevated to a Scientific Induction. Again, in DEDUCTION, as in Analogy, we base our inference on resemblance In Deduction, we argue—

Deduction.

All men are mortal
Socrates is a man
∴ Socrates is mortal.

That is, Socrates resembles other men in some respects and therefore, will resemble other men also in being mortal. The difference between a deductive argument and an Analogy, however, is that in Deduction, one of the premises of every syllogism furnishes a general law which is wanting in an analogical reasoning. If, for example, there had been such a general law as "All planets are inhabited" we could have drawn the conclusion 'Mars is inhabited' by Deduction.

Thus the ground of all kinds of inference, inductive, deductive as well as analogical, is *Resemblance* only, in Analogy, the resemblance is of an imperfect character.

Sec. 4. Analogy and Scientific Induction.

Analogy is a sub-division of Induction.

According to **Mill**, Inductions proper are of three kinds, *viz*, Scientific Induction, Induction per Simple Enumeration, and Analogy. The essence of Induction, according to Mill, consists in an "inductive leap" from the known to the unknown, and as this characteristic is present in Analogy, it should be recognised as a sub-division of Induction proper. Analogy, however, is a weak form of inductive argument, because it is based on imperfect similarity. Let us fully understand the nature of analogical reasoning by contrasting it with Scientific Induction.

As contrasted with Scientific Induction.
(*a*) In Analogy we proceed from the particular to the particular

(a) In Scientific Induction (and also in Induction per Simple Enumeration) we proceed from the particular to the general, while in Analogy, we proceed from the particular to the particular.

In Scientific Induction, on an observation of a number of particular instances we establish a general proposition; in Analogy, on the other hand, on an observation of one particular instance, we pass on to another particular instance which has not been observed. When on an examination of several cases of death, we arrive at the general proposition, All men are mortal, we have a Scientific Induction; but when observing certain features of a particular planet, *viz.*, the Earth, we draw some conclusion in respect of another particular planet, *viz.*, Mars, we have an Analogy.

In Analogy we explicitly argue from particular to particular but implicitly from particular to universal.

Mill's description of 'Analogy' as an argument from particular to particular must not be taken literally. If we argue from one particular to another particular which resembles the former in certain attributes, we do so because we have implicitly formed in our minds a *Universal* representing the common attributes, and we unconsciously bring both the instances under that Universal. The difference between Analogy and Induction therefore is that while in Induction we consciously express the universal in the form of a general proposition, we do not do so in Analogy, though in both cases we rely on the *universal element in the particulars* as the ground of inference. Hence at best we can say that Analogy—as long as it remains Analogy only—"sticks in the particular instances", without working out a law of connection between them.

(b) In Analogy there is no knowledge of a causal connection;

(*b*) *Scientific Induction is based on the knowledge of a causal connection, while in Analogy, there is no such knowledge.*

In Scientific Induction, we establish a causal connection by the application of the Experimental Methods, but in analogical reasoning, no such causal connection is established or known to exist. In Analogy we do not work out a law of connection between phenomena by comparing a number of ins-

tances or by using the methods of Scientific Induction. We merely find a resemblance between some circumstance in the phenomenon to be explained and some phenomenon with which we are already familiar, and we use the latter as a basis for the conclusions about the former.

(c) Analogical conclusions are probable; Inductive conclusions are certain

(c) *Analogy yields merely probable conclusions while conclusions in Scientific Induction are certain.* It is true that probability is a matter of degrees, and an analogical argument may have varying degrees of probability from zero almost up to the level of certainty. But an analogical argument, however strong, cannot reach the certainty of Scientific Induction. In Scientific Induction, a causal connection is known to exist and thus the conclusion necessarily follows. In Analogy, on the other hand, the similarity is more or less imperfect, and as such, an element of doubt must always attach to the conclusion.

(d) Analogy is a stepping-stone to Scientific Induction

(d) Lastly, *Analogy may be described as a stepping-stone to Scientific Induction* In Analogy, no causal connection is *known* to exist. It is certainly not true that in Analogy, it is known that a causal connection does not exist. On the other hand, there is a vague belief that though no causal connection is at present known to exist, such a connection will at some future time be discovered, and the analogical argument will perfect itself into a Scientific Induction. Till this desired goal is reached, Analogy is regarded as a stage on the road to Scientific Induction or to use the words of **Mill** 'a guide-post pointing out the direction in which more rigorous investigations should be prosecuted'. Analogy is a source of hypotheses which, when proved, result in Scientific Induction.

Note. Analogy and Simple Enumeration.

Analogy and Simple Enumeration compared.

In Induction per Simple Enumeration, we argue that because, several instances of one kind, (crows) exhibit a particular attribute (blackness), it follows that all crows are black. In Analogy, because two particular things, (the Earth and Mars) agree in certain respects, we infer that they will agree in other respects. Thus Induction per Simple Enumeration may be said to deal with the denotation of terms; it increases our knowledge of the denotation of the term 'crow', in the concrete instance mentioned above. On the other hand, Analogy deals with the connotation of a term; in the concrete example, our knowledge of the connotation of the term 'Mars' is increased. But as denotation and connotation are intimately connected, these two forms of inference merge into each other The real distinction between them appears to be that in Simple Enumeration, we pass from particular instances to a general proposition, in Analogy, we pass from one particular instance to another particular instance, without consciously bringing these instances under a general proposition.

Sec. 5. Strength of Analogical Argument.

Analogical argument is probable and not certain; but probability is a matter of degrees.

Analogy is based on imperfect similarity and its conclusions are accordingly probable in character. But probability is not a fixed quantity but is a matter of degrees. An argument from Analogy may have any degree of probability from zero almost up to the limit of certainty Now let us consider the conditions on which the strength of an analogical argument depends.

The value of Analogy depends on

According to **Mill**, the value of an analogical argument depends "on the extent of *ascertained resemblance*, compared first with the amount of *ascertained difference* and next with the extent of unexplored region of *unascertained* properties" To quote the words of **Bain**: "The probability is measured by comparing *the number and importance of the points of agreement* with the *number and importance of the points of difference*, having respect also to the *extent of unknown properties* as compared with the known".

(a) the number and importance of the points of similarity, as contrasted with

(a) *Firstly, the greater the number and the importance of the known points of resemblance, the greater the value of the analogical argument.* For example, the points of resemblance between men and lower animals are more numerous and more important that the points of resemblance between men and plants. Hence the analogical argument 'Lower animals feel pleasure and pain as men do' is more probable than the argument 'Plants feel pleasure and pain as men do'.

(b) the number and importance of the points of difference, and

(b) *Secondly, the greater the number and the importance of the known points of difference, the less the value of the analogical argument.* For example, the known points of difference between the Earth and the Moon are more numerous and more important than those between the Earth and Mars. Thus the Moon has no atmosphere while Air is an indispensable condition of life on the Earth. Hence the absence of atmosphere is an important point of difference. The known points of difference between the Earth and Mars however are less numerous and less important than those between the Earth and the Moon. Hence the argument, 'The Moon is inhabited like the Earth' is less probable than the argument 'Mars is inhabited like the Earth'.

(c) the number of unknown points.

(c) *Lastly, the greater the number of unknown points as compared with the number of known points, the less the value of the analogical argument.*

Thus where the resemblance is very great, the difference is very small and our knowledge is sufficiently extensive, the analogical argument may approach in strength very near to an Induction but of course it can never amount to exactly the same certainty as Induction.

It should be noted that the value of an argument from Analogy depends not merely on the *number* of the points of agreement but also on their *importance*. Other things being equal, the more the number of the points of resemblance, the greater is the value of the Analogy; but this is not the same thing as to say that the value of the conclusion is in direct proportion to the number of the points of resemblance which can be discovered. For example, we may argue in this way: Two men are of the same stature, of the same age, bear the same initials,, live in the same house, come from the same native town; one of them is keenly intelligent; therefore, the other must also be so. In this case the analogical argument is worthless because none of the points of resemblance has any importance whatsoever. Hence **Welton** remarks: "The force of an argument from Analogy depends on the *character* of identity and not on the *amount* of similarity". As **Bosanquet** says: "*We must weigh the points of resemblance rather than count them.*"

The value of Analogy depends more on the *importance* of the similarity than on their *number*

The value of an analogical argument has been expressed by some Logicians mathematically in the form of a **Fraction** thus:—

Representation in the form of a fraction.

$$\frac{\text{Resemblance}}{\text{Difference} + \text{Unknown points}}$$

The significance of this mathematical representation is this. The numerator consists of factors which make for strength, and the denominator consists of factors which weaken the force of the argument, so that the fraction represents the value of a particular argument from Analogy. We must not think however that it is possible to determine the value of any parti-

cular argument in exact mathematical ratio. The fraction given above merely expresses in a general way that the number and the importance of resemblances constitute a favourable factor, and the other two constitute an adverse factor in determining the value of an analogical argument.

Criticism.

Criticism

From the above it might appear that the estimation of the value of an analogical argument is a mechanical process such as we have in Mathematics. But it should be noted that the process is not an easy one at all. Two main difficulties may be pointed out. *Firstly*, two different principles are involved, *viz.*, *Number* of points, and their *importance*. In practice, it is often impossible to reconcile them. Again, the number of points of similarity is a matter of comparative indifference when their importance is small. Hence it is difficult to decide whether in a given case, number or importance should be the guiding factor. *Secondly*, it is futile to talk of the number of unknown points. If they are unknown, how should we know how many they are? The 'unknown' cannot be used as a standard of comparison.

Sec. 6. Good and Bad Analogy: False Analogy.

False Analogy is based on superficial points of similarity

The strength of Analogy depends on the number and the importance of the points of similarity, as contrasted with the number and the importance of the points of difference, and the number of the unknown points. Hence, a **Good Analogy** means an argument in which a conclusion is drawn from the presence of essential resemblance between two

things. A **Bad Analogy** or a **False Analogy** is one in which the conclusion is drawn from superficial points of resemblance. As **Fowler** puts it. "The term False Analogy is..............applied to those cases of analogical inference in which there exists no ground for analogy whatever". Thus False Analogy is a fallacious analogical argument in which we confuse between essential and inessential points of similarity.

Examples of False Analogy due to confusion between essential and inessential points.

(i) *A nation, like an individual, must pass through periods of growth, maturity and decay.* This is a False Analogy, because the likeness between a nation and an individual palpably fails in most important points. A nation's losses are repaired, the physical decay of a human being after a period is irreparable.

(ii) *If justice consists in keeping property safe, the just man must be a kind of thief, for the same kind of skill which enables a man to defend property, will also enable him to steal it* This False Analogy is humorously put into the mouth of Socrates by Plato in *the Republic* The point of similarity mentioned here between a just man and a thief is that they both possess similar skill in defending property. They both *can* keep property safe But there is the most important point of difference, *viz*, while a just man is not merely a man who *can*, but a man who *does*, keep property safe, while a thief can, but does not, keep property safe Their *capacities* may be similar but from this similarity we cannot infer that their *acts* are also similar.

(iii) *Plants, like men, have birth, growth, and decay and death Men possess intelligence; therefore plants also possess intelligence* This is a false analogy, because there is no essential connection between the points of resemblance and the inferred property.

(iv) *Lower animals, like men, not only possess life but sometimes exhibit signs of intelligence; e g, bees construct a highly complex hive. Therefore, it is argued that they possess an intelligence of the human kind* This is wrong, because the bee can construct only one kind of hive, and this is due to instinct Man can build various kinds of structures according to his requirements (If, however, it be argued that lower animals like men possess life and therefore, they are subject to pleasure and pain like men,

connection between life and susceptibility to pleasure and it would be a good analogy, because there is an important pain.)

(*v*) Sometimes, analogy may be fantastic. Suppose, we argue that *gramophones are intelligent, because, like men, they appear to sing, laugh, talk, etc.* That would be ridiculous. Similarly, it is ridiculous to think that *two persons whose names begin with the same letter of the alphabet will have similar intelligence; two students coming from the same native district, having a similar complexion, wearing the same kind of clothes, parting their hair in a similar way, professing the same religion, prosecuting their studies in the same educational institution and so on, will possess similar degree of intelligence* The student will find a highly fantastic example of false analogy in Shakespeare's Henry V, Act IV, Scene 7, where a particular character in the drama, Fluellen says that *King Henry's life will be similar to that of Alexander the Great, because they were both born in places the names of which begin with* M, Monmouth in the case of King Henry, and Macedon in the case of Alexander the Great, that in both places there was a river and that there were salmons in both, and that both Kings resembled each other in their rages, furies, wrath, cholers, moods and so on.

The expression 'False Analogy' is sometimes used also to include fallacious arguments due to an improper use of metaphorical language. Metaphors and Similies are good devices to emphasise points of similarity but they should not be mistaken for good arguments and should not be pressed too far.

Examples of False Analogy due to improper use of metaphorical language :

(*i*) *The metropolis of a country is similar in many respects to the heart of the animal body, therefore, the increased size of the metropolis is a disease* Figuratively, it may be permissible to liken the 'metropolis' to the 'heart' of a natural body but to argue that such likeness would subject the metropolis to a disease peculiar to animals is an improper use of metaphor.

(*ii*) Talking of London, Smollett (British author 1721-1771) says· *"The capital is become an overgrown monster; which like a dropsical head, will in time leave the body and extremities without nourishment and support What wonder that our villages are depopulated, and our farms in want of day-labourers?"* This is False Analogy because the abnormal influx of labour in the capital from the villages is

no doubt an evil but the growth of the capital is the effect of this influx, and not its cause, and therefore the consequent evils are not analogous to "leaving the body and extremities without nourishment and support"

(iii) *Tariff walls hinder trade, for a wall is always an obstacle to communication.* This is also a False Analogy because the analogy has been pressed too far No doubt a wall is an obstacle but it is also a protection for those who take shelter within it. Tariffs are analogous to a wall because they seek to promote infant indigenous industries from undue foreign competition.

(iv) *It is the duty of colonists to obey the mother-country* The point of analogy here is that the relation between the mother and the child is similar to that between the mother-country and the colonies. This is correct so far as it goes, but to infer that obedience is due to the mother-country is pressing the analogy too far because the colonies have the right to pursue their own development and sometimes it may cause a conflict of interests with the interests of the mother-country.

EXERCISE VI.

1 Explain the nature of Inference from Analogy. Give both a symbolical and concrete example, stating them in their simplest logical forms.

2 How would you distinguish induction from analogy? What is the value of an argument based on analogy?

3 What is Argument from Analogy? How does it differ from Induction and Deduction?

4 Discuss the nature, value and uses of *analogical reasoning* How does Analogy differ from Induction and generalisation?

5. Discuss the nature, value and validity of Inference from Analogy. Wherein does it agree with, or differ from Scientific Induction?

6 On what does the strength of analogical reasoning depend? Give an example of a good and an example of a bad analogical reasoning.

7 How is the strength of an Analogical argument measured?

8 "In Analogy we must *weigh* the points of resemblance, not simply *count* them." Discuss.

9 Explain the functions of Analogy in Induction.

10 'The foundation and justification for all inference is Similarity' (p 221). Explain this and account for the difference between analogy and induction as methods of proof

11 "All Inductive Reasoning is analogical" Discuss this. Explain the distinction between Induction and Analogy (p. 220).

12 In what sense is Analogy described as incomplete Induction? Explain the view that in an analogical argument we argue explicitly from particular to particular but implicitly from particular to universal

13 Show how the value of an Analogy may be represented by a fraction having as its numerator the resemblances between the things compared and as its denominator the differences between them *plus* the number of qualities of which we are ignorant regarding them.

14. The value of an Analogical argument depends on the *degree* as well as the *kind* of resemblance. Show by examples how one kind of resemblance may be more important than another as the ground of inference.

15 Compare Analogy with Enumerative Induction.

16 "An Argument from Analogy can only be more or less probable; if it amounts to certainty, it ceases to be analogical." Explain fully.

17 What are the principles upon which Analogy is based? According to some, Induction is Analogy Do you agree?

EXERCISES FOR ADVANCED STUDENTS.

1 Explain what analogy is, and describe its value in science. Why is an argument from analogy said to have less cogency than one which calls out all the resources of the Inductive Method?

2. "Analogy has little probative force; its value lies in suggestiveness" Explain this statement, and comment on it

3. Examine the statement that a sound Analogy is nothing but a well-grounded hypothesis, and stands as much in need of verification as any other hypothesis.

4 What cautions should be observed in analogical reasoning? Give examples of faulty analogical reasoning from the standpoint of the cautions named.

5 Why do we speak of Analogy as Incomplete Explanation?

6 If all analogical reasoning yield only probability is not one analogy as good as another for purposes of inference?

7 State some of the propositions which may serve as proximate principles of analogy.

8. What analogies appear in the following propositions?

(1) War is blood-letting.
(2) War is the exercise of a nation's organism.
(3) The advocates of prohibition are fanatics.
(4) Only socialists would propose such a measure
(5) Teddy is a bookworm
(6) At the time of the murder my client was in a twilight sleep.

CHAPTER VII.

NATURE, PLACE AND USE OF THE DEDUCTIVE METHOD.

Sec. 1. Introductory: Difficulties of the Experimental Methods.

The Theory of Probability and the Deductive Method

The chief difficulties which frustrate the Experimental Methods are the Plurality of Causes and the Intermixture of Effects. In the next chapter, we shall consider how the Theory of Probability or Calculation of Chances affords some relief in the case of the Plurality of Causes. In this chapter we shall consider how the difficulties arising out of the Intermixture of Effects can be overcome.

Intermixture of Effects and the Experimental Methods.

Intermixture of Effects may be homogeneous or heteropathic

The Intermixture of Effects assumes *two* forms, *viz.*, Homogeneous and Heteropathic. In *Homogeneous Intermixture*, the separate effect of each of the causes continues to be produced, and these separate effects unite into one aggregate—the complex effect. In *Heteropathic Intermixture*, the separate effect of each cause ceases entirely, and the complex effect is a wholly different phenomenon. The Heteropathic Intermixture of Effects sometimes assumes a special

Some forms of heteropathic intermixture can be dealt with by experiment but the Experimental Methods are of no avail in dealing with homogeneous intermixture.

form, *viz.*, **Transformations,** in which cause and effect are mutually convertible; for instance, hydrogen and oxygen produce water, and again, water produces hydrogen and oxygen (Ch. II, Sec. 10, Note 3, p. 104). This form of Heteropathic complex effect can be dealt with easily by experiment, and therefore the Experimental Methods can be used in such cases But other forms of complex effects, particularly those which result from a Homogeneous Intermixture of Effects, cannot be dealt with by the Experimental Methods. In Homogeneous Intermixture, there are several causes and each has only a share in the production of the complex effect Hence, the more numerous the causes, and the smaller the share of each, the more difficult is the application of the Experimental Methods **Mill** shows that in the investigations of a complex effect, the Method of Observation and the Method of Experiment are alike inapplicable.

Example

Method of Observation (Agreement, Joint Method and Concomitant Variations) inapplicable

To take an *example* of a complex effect "recovery from consumption" The question is—Is the taking of cod-liver oil one of its causes? *The Method of Simple Observation is inapplicable* It is clear that many separate causes must combine to produce the effect As many causes are acting jointly, the share of each cause in the production of the effect is very small, and hence, the effect is not likely to follow any single cause, in its presence or absence, or in its variations Hence, the Method of Agreement, the Joint Method and the Method of Concomitant Variations, when applied as a method of Observation, are of no avail. *The Method of Experiment is alike inapplicable,* because we are not able to take certain precautions necessary for the employment of Experiment. For instance, experiment requires that no unknown circumstances should exist When we administer cod-liver oil, we cannot know everything in the system of the patient which can influence consumption. Thus the Method of Difference is of no avail.

Method of Experiment (Difference) inapplicable

Hence the most that we can hope to obtain by the Experimental Methods in the case of complex effects is that a given cause is *very often* followed by a given effect, but this is very far indeed from saying that we are able to ascertain causal connection.

Mill points out that in all cases of the inapplicability of the Experimental Methods, our resource is *the Deductive Method.* Thus the Deductive Method is applied to those complex cases, where the methods of direct observation and experiment are insufficient or inapplicable

Hence we apply the Deductive

Sec. 2. Forms of the Deductive Method.

The Deductive Method assumes *three* forms, *viz.*, the *Direct* Deductive Method or the *Physical Method,* the *Inverse* Deductive Method or the *Historical Method,* and lastly, the *Abstract* Deductive Method or the *Geometrical Method* Let us deal with these methods separately.

A. THE DIRECT DEDUCTIVE METHOD OR THE PHYSICAL METHOD

The **Direct Deductive Method** involves the following *three* steps, *viz.*, Ascertaining the laws of the separate causes by direct induction; Ratiocination or Deduction; and thirdly, Verification; thus :—

A. Direct Deductive Method.

(i) *Ascertaining the laws of the separate causes by direct Induction.*

(i) Previous Induction gives us knowledge of causes and their laws.

At the first stage we provisionally accept the conclusions of previous Induction. Induction supplies us with a knowledge of causes and their laws with the help of the experimental methods. This know-

These are assumed provisionally to be true.

ledge is not conclusive, and the Deductive Method is employed to test the correctness of this knowledge. But to start with, we provisionally accept the conclusions of Induction. When a complex effect is given, we ascertain from previously established inductions what the separate causes and their laws are likely to be. If Induction does not supply such knowledge, we frame hypotheses about them

(ii) Joint result is ascertained by Calculation (Deduction).

(ii) Ratiocination.

The next step is Ratiocination, which consists in calculating from the laws of the separate causes what effect they must produce jointly. At the previous stage, the likely causes and their laws are ascertained. At this stage, we calculate what their joint effect should be. *This is the stage of Deduction in the Deductive Method.*

(iii) Verification by Observation or Experiment. (Induction).

(iii) Verification.

Lastly, we must verify the calculated result, *i.e.*, we appeal to the facts of experience in order to see whether the calculated result actually tallies with them. If we stop at the second stage, the deductive calculation is nothing more than guesswork. The calculated result must agree with facts. If it does not agree, there must be a defect at the first stage, *i.e.*, we have not taken into account all the causes and their laws, or we have committed some error in calculating their joint effect. Hence, Verification is the most important stage in this method. *This is the stage of Induction in the Deductive Method.*

Hence, we sum up in the words of **Carveth Read**: "Give any complex mechanical phenomenon, the inquirer considers—(1) what laws already

ascertained by induction seem likely to apply to it (in default of known laws, hypotheses are substituted); (2) he then computes the effect that will follow from these laws in circumstances similar to the case before him; and (3) he verifies his conclusion by comparing it with the actual phenomenon".

Example

As an EXAMPLE of the Direct Deductive Method we take the following. We want to ascertain *the law relating to the path described by projectiles. Firstly,* we ascertain the causes. We ascertain from previous Induction that there are three forces at work, *viz.*, the force of gravity which tends to make the body fall to the earth, the force of the projectile by which it tends to move in a straight line, and lastly, the resistance of the air, which tends to diminish the velocity of the body. At the *second* stage, we calculate the joint action of these three forces and arrive at the conclusion by our knowledge of mathematics, that the path, the projectile should describe, is a parabola. This is Deduction. At the *third stage* of Verification, the calculated result is found to agree with facts when experiments are made with cannon balls or such other things.

Also called the Physical Method.

The Direct Deductive Method has been called by Mill, the **Physical Method** because, it is so much used in the Physical Sciences. It may be pointed out that though it is mainly applied to the investigation of physical phenomena, it may also be applied in other spheres.

B. THE INVERSE DEDUCTIVE METHOD.

B The Inverse Deductive Method We first *observe* and then *deduce* the observed facts from higher

In the **Inverse Deductive Method,** we seek to determine the cause of a complex effect in the following way. We first observe certain instances in which the phenomenon occurs and find that so far as experience goes, it is associated with certain circumstances. Then we endeavour to show that the nature

laws; first Observation (Induction) then Deduction.

of these circumstances is such that it is but natural that the phenomenon should occur. Thus in it, a complex effect is sought to be proved by deducing it from higher laws. The first stage is Induction (Observation) and then comes Deduction.

Example.

To take an EXAMPLE: Suppose we want to ascertain the cause of a political revolution We examine several instances of political revolution and find in every case, certain circumstances are present, *viz.*, the people are poor, the government is oppressive and so on We then endeavour to show that where such causes as the poverty of the people, bad government, etc, are present, it is but natural that revolution should follow. Thus what is observed is proved by deduction from higher laws Deduction from higher laws proves facts previously observed.

Direct and Inverse methods compared.

Let us now compare the Inverse Deductive Method with the Direct Deductive Method Both of them take the help of Induction as well as Deduction in order to ascertain the cause of a complex effect. In the Direct Deductive Method, however, we first assume some causes, then calculate their joint effect, and lastly, verify the result by appealing to experience. The first two stages consist in assuming causes and deductively calculating their results, and the last stage is the stage of Induction in which Observation or Experiment verifies the previous deduction. Thus deduction comes first, and then induction follows. Hence this is called the Direct Deductive Method. In the Inverse Method, Induction comes first, because we first observe the features of the phenomenon, and then by Deduction from higher principles we seek to prove that the phenomenon follows from them. In the Direct Deductive Method, Induction (as Observation or Experiment) verifies a previous Deduction (Calculation of the effect of supposed joint causes); while

in the Inverse Deductive Method, Deduction from higher laws verifies Induction (facts observed). In the Direct Method, Deduction takes the lead and Induction follows; while in the Inverse Method, Induction takes the lead and Deduction follows.

The Inverse Method is also called the Historical method.

The Inverse Deductive Method is called the **Historical Method**, because it is chiefly resorted to in the historical sciences, such as History, Politics, Sociology, etc. We have seen that the Direct Deductive Method has been called the Physical Method, because, it is generally used in the Physical Sciences. It should not be thought that the Direct Method and the Inverse Method are confined to physical sciences and historical sciences respectively The fact is that when the causes determining a complex effect are so numerous or so indefinite, that a calculation of their joint effect cannot be made beforehand, the Historical Method is likely to be useful.

C. THE ABSTRACT DEDUCTIVE METHOD OR THE GEOMETRICAL METHOD.

C. The Abstract Deductive Method or the Geometrical Method is a purely deductive method

The Direct Deductive Method and the Inverse Deductive Method both employ Deduction as well as Induction, though in different order. Hence, **Jevons** calls them the *Combined or Complex Method*. They are further called the *Concrete Deductive Method,* to distinguish them from what is called the Abstract Deductive Method or the Geometrical Method. **The Abstract Deductive Method** or the **Geometrical Method** does not make use of Induction at all but uses Deduction only. In it, there is no question of Observation or of Verification by an appeal to experience, because, it deals with abstraction and not

with concrete phenomena. Geometry employs the Abstract Deductive Method. Geometry deals with such abstractions as point, line, etc., which are very different indeed from physical points, physical lines, etc. As it deals with abstractions merely, there are no counteracting factors, and if the deduction be correctly drawn there is no possibility of any error. Thus, from the properties of a triangle, the conclusion is drawn that its three angles are equal to two right angles.

From the above account it is quite clear that there is hardly any justification for dealing with this method in Inductive Logic. It is deductive, pure and simple. The only apology perhaps is that sometimes thinkers have sought to employ the Geometrical Method beyond its proper sphere, *e.g.*, in Politics, Ethics, and Religion. For instance, from the general principle, that man is rational, it is deduced that he is free to think as he likes, without paying any heed to agencies which fetter his freedom in this as in other respects.

EXERCISE VII.

1. Mill and Bain think that three operations are implied in the full scope of the Deductive Method, *viz.*, Induction, Deduction proper, and Verification Explain the exact meaning of each and exhibit their relation to one another, making your meaning clear by means of examples.
2. What is the Deductive Method employed in inductive investigation? Distinguish between the Direct and the Inverse forms of this method
3. Discuss the part played by deductive reasoning in inductive enquiry
4. What is meant by a Deductive and what, by an Inductive Science State the principal Deductive and Inductive Sciences

[**Answer:** A Deductive Science is that which deduces conclusions from certain accepted principles while an Inductive Science is that which establishes general laws from facts of experience. It is clear, therefore, that as Inductive Sciences make more and more progress, more and more

laws are established, and then, further progress even in the case of the inductive sciences consists in applying deduction. That is to say, the Deductive Method, a combination of Deduction and Induction, is employed. Hence it has been said that as the sciences develop, they become more and more deductive *Mathematics, Geometry, Mechanics, etc.*, are the main deductive sciences, dealing with abstract principles. They start with certain general principles and deduce consequences from them. *Physics, Chemistry, Botany, Biology, Zoology,* etc., are the main inductive sciences because, they start with facts of experience and seek to discover laws from them.]

5. It has been said that probably the greatest merit in Mill's logical writings is that he points out the entire insufficiency of what is called the Baconian Method to detect the more obscure and difficult laws of Nature. Explain what the Baconian Method is, and in what respects, Mill differs from it.

[**Answer:** This is a quotation from *Jevons' Elementary Lessons*, page 255. The Baconian Method consists in Observation, including Analysis and Elimination by Varying the circumstances. Bacon protested against the process of "anticipating nature," *i e*, framing hypotheses for the investigation of natural phenomena Bacon further condemned the Method of Deduction (See Ch. 1, Appendix 3, p. 61.) Mill also undervalues the importance of Hypothesis in Induction and holds that the framing of Hypothesis is no concern of Induction He however does not ignore hypotheses altogether. But the chief difference between the method of Mill and the method of Bacon consists in Mill's recognising the Deductive Method Mill frankly admits that the Experimental Methods which are the chief weapons of the Pure Inductive Method are of no avail in dealing with complex physical or historical phenomena, and points out that those complex effects can only be studied with the help of the Deductive Method or as Jevons calls it the Combined or Complete Method, alternately making use of Deduction and Induction]

6. Why are social phenomena so difficult to treat scientifically? What methods may be employed in treating them?

7 Describe the so-called "Deductive Method", and explain for what kinds of subjects it needs to be used in contrast with the so-called "experimental methods".

8 Explain the so-called 'Deductive Method'. Describe the Physical Method, and give an example to show its application

CHAPTER VIII.

CHANCE AND ITS ELIMINATION :

THEORY OF PROBABILITY : STATISTICS.

Sec. 1. Introductory.

The difficulty arising out of a possibility of there being more than one cause can be met, to some extent, by the theory of Probability.

In the preceding chapter, we have seen how the difficulties arising out of the Intermixture of Effects can be overcome by the application of the Deductive Method. In this chapter, we shall examine how the difficulties arising out of the doctrine of Plurality of Causes can be, *to some extent*, met by the theory of Probability or the Doctrine of Chance. According to Plurality of Causes, an effect X may be produced by either A or B or C. The Method of Agreement fails to determine this question conclusively In cases where conclusive and certain results cannot be attained, we remain content with probable results The theory of probability formulates certain rules by the application of which we seek to determine whether the probability of A being the cause of X is greater or less than the probability of B or C being the cause If we find that A and X go together frequently, we conclude that it is not a case of accident or chance but that there is some relation between the two Or, in other words, there is probably some *causal connection*, and that it is not a casual coincidence Let us, therefore, attempt to understand the concepts of Chance and Probability, and their conditions.

Sec. 2. Chance.

Chance is not the denial of causality. Nothing is due to Chance in the sense that it is causeless. Every event in the universe, everything that happens in the world, has a cause. But there are phenomena occurring at a certain point of time and space, which have *no obvious causal connection* with one another. Their occurrence or occurring together, in time or space, is a "chance coincidence". For example, a man speaks of having "chanced" to meet an old friend, after a long time, at a certain street corner, at a particular moment of time, when he was waiting for the tram car. It was a chance coincidence, because the occurrence was unexpected. Thus, when two events, not connected with each other as cause and effect, coincide or occur together, we regard the coincidence as due to "Chance", because, we are unable to explain or account for it, by any effort of ours. Similarly, there are events whose recurrence is so irregular or uncertain, that we are unable to trace the laws according to which their causes combine to produce them. Supposing in a game of dice, there are twenty throws, and we find that the faces showing three and five have turned up four times each, the faces showing two and four, thrice each, and the faces showing one and six, thrice each. If there are twenty throws again, the results would not be the same. Such phenomena or events we describe as matters of mere Chance or accident. Similarly, if we toss a coin, and the "head" turns up and not the "tail", we say it is due to Chance.

An event is said to be due to Chance, when no causal connection is known to exist

Examples.

When, however, we say that two events occur together by Chance (as meeting an old friend in a

Chance does not mean that there is no causal connection

street corner, or an occurrence of the sort of a coin being tossed and the "head" turning up), we do not mean to deny that the actual result was produced by a number of causes acting together. We merely mean that *we are unable to see how it happened.* We are unable to see anything in the tossing of a coin which necessitates the turning up of the "head", rather than the "tail". On the other hand, we think that if we understood all things and knew all causes, we could have explained why a particular event occurred or why two events which do not appear to us to have any connection with each other occur together. We come to this conclusion on the ground that every event in the universe has a cause, and if we are unable to trace the cause in a given case, it is because of our imperfect intelligence. If there be an Omniscient Intelligence, He would know all and for Him, there can be no such thing as Chance. So far as we are concerned, such perfect knowledge is not attainable, because our powers are limited and because the phenomena of Nature are highly complex. Hence "Chance is but law unknown".

Chance therefore means ignorance of causal connection on account of the vastness and complexity of Nature.

Thus though for an Omniscient Intelligence there is no such thing as Chance, and we think an event or a coincidence is due to Chance because of the finiteness of our intelligence, yet *the conception of Chance is not purely subjective.* It is true that we are *ignorant* of the causes, but this *ignorance is due to the objective fact that Nature is so vast and so complex.*

Definition

Thus Chance has been defined by **Mill** as **coincidence giving no ground to infer uniformity**. 'We say some event is due to Chance, because we

are unable to infer a causal connection on account of the complexity of natural phenomena.

Sec. 3. Elimination of Chance.

If two events occur together frequently, there is probably a causal connection, otherwise not.

The Elimination of Chance is a method by which we show that the conjunction between two events is not *casual, i.e.*, due to Chance, but that it is *causal, i.e.*, due to the operation of some causes. This method is based on the principle that if two events are connected by Chance alone, their connection will not be frequent. If they coincide frequently, there is *probably* a causal connection; if they coincide rarely, there is *probably* no causal connection.

Bain.

Bain formulates the following rule for the elimination of Chance:

"Consider the positive frequency of the phenomena themselves, and how great frequency of coincidence must follow from that, supposing there is neither connexion nor repugnance. If there be a greater frequency, there is connexion; if a less, repugnance."

Examples.

By the phrase *"positive frequency"* Bain means the number of times each of the conjoined events would occur naturally. Thus suppose we are considering whether there is any connection between a red sky and rain, we should first determine the frequency with which each phenomenon will occur. Suppose we find that a red sky occurs once in three days, and rain only once in seven days, then in every twenty-one days, they should occur once together. This is the frequency, which is to be expected if the two

events are due to Chance; if we find that as a matter of fact, they occur together more frequently, then we infer that there is a connection; if, on the other hand, we observe, that they occur less frequently, we infer that there is a repugnance between them.

To take another illustration. Supposing in a game of dice, the number six turns up very frequently. The question arises whether the appearance of six is a purely casual result of the throw or due to its being loaded. We know that if the die be a normal one, it ought to turn up once in six times on an average. But if in a given case, it turns up five times in every six, we conclude that there is something wrong somewhere.

Chance and Probability.

Now there arises a *difficulty*. It is only if the number of throws be infinite that we can expect each face of the die will turn up once in six times. There is nothing impossible in a normal die turning up one face four times in the first six throws. Though this is well above the average, from this circumstance alone we would not be justified in inferring that it is loaded. At most we can suspect that it is *probably* loaded. If there are, say, 1000 throws and a similar excess is maintained, the probability that it is loaded increases. But however large the number from which the average is obtained, it is always a question of greater or less probability. Only if the number be infinite, can we expect certainty. But an infinite number is impossible. Hence, the question of the Elimination of Chances is bound up with question of Probability.

Sec. 4. Probability.

Scientifically, Probability means anything between Impossibility and Certainty. Popularly, it means something more likely to happen than not.

The word 'Probability' is ambiguous. The ordinary popular meaning of the word is different from its scientific meaning. *Ordinarily,* when we say that an event is probable, we mean that it is more likely to happen than not. An event which happens but rarely is not popularly called 'probable', but something which is merely 'possible'. Thus in ordinary life, we draw a distinction between 'possibility' and 'probability'. A thing is *possible,* if it does not involve self-contradiction; in this sense, a golden mountain is *possible,* but it is not probable, in the popular sense of the term. *Scientifically,* however, *an event is probable, if, on the one hand, it is not impossible, and on the other, not certain.* If the thing be self-contradictory, it is absolutely impossible; again, there are some things which are certain; when, for instance, a causal connection is proved, we attain certainty. *Probability,* therefore, in the scientific sense of the term, *is a matter of degrees, extending from something better than Impossibility but worse than Certainty.* Hence, what is called possible, in the ordinary sense of the term, is also probable in the scientific sense.

Probability as a Fraction.

Probability has been represented as a **fraction.** Supposing 1 stands for Certainty, and 0 stands for Impossibility, Probability would be a fraction; it may be 999/1000 or 1/1000 The denominator represents the number of times that an event happens, and the numerator stands for the number of times that it happens along with another event. In a game of dice, the probability of the six turning up is expressed by putting the number of throws for the denominator, and the number of times the six is thrown, for the

numerator. We have seen that in a sufficient number of throws, the probability of the six turning up would be 1/6 or in other words, it is likely to turn up once in six throws.

robabi-ty as a roportion

Sometimes, Probability is represented as a **proportion.** If the fraction expressing the probability of the six turning up is 1/6, the proportion of cases in which it happens is 1 to 5. This is expressed by saying that the chances in favour of its happening are 1 : 5; or the chances against its happening are 5 : 1.

We have already understood in a general way in what class of cases, the question of Probability arises. In those cases, where we know that in a limited number of occurrences, the event must happen several times, and yet we do not know, whether in a particular instance it will happen, we proceed to estimate its probability. We believe that there are certain laws governing the event, and hence it must happen. But our knowledge of causes and their laws is imperfect. If our knowledge were perfect, we would expect that the event would certainly happen, but knowledge being imperfect, we estimate its probability.

Sec. 5. Grounds of Probability.

Two views:— (i) Probability is purely subjective.

There is a difference of opinion as to the grounds of Probability. Some Logicians (*e.g.*, **Jevons**) **are of** opinion that its grounds are *purely subjective, i.e.*, Probability depends upon the quantity of our belief in the happening of a certain event, or in its happening in a particular way. According to others, the ground is *objective, i.e.*, Probability depends on experience.

Carveth Read points out that the view that Probability is purely subjective is unsound for the following reasons:— Criticism.

(a) *Firstly, Belief cannot be satisfactorily measured.* It cannot be said that belief, as a mere state of the mind, can be expressed in the form of a fraction. If a number of letters be mixed up in a bag and we only know that one of them is X, we draw the letters one by one, endeavouring each time to estimate the value of the belief that the next time X will turn up, can we say that our belief in the drawing of X next time increases as the number of letters decreases?

(b) *Secondly, Belief does not uniformly correspond with the state of facts.* Belief is a state of the mind which is subject to hope and fear, temperament, passion and prejudice, etc., and does not depend merely on experience. The experience of two men may be the same but one may think he has seen a ghost, whereas, a man who is not superstitious would say he only saw some object dimly lighted by the moon. Hence, if it is merely a question of belief, we cannot estimate probability.

(c) *Thirdly, if Probability is to be connected with Inductive Logic, it must have some relation with experience,* from which the materials of Induction are obtained. Induction is not concerned with mere belief, but with belief which is grounded on facts. Therefore, the view that Probability is merely subjective is wrong.

Hence we conclude that Probability as dealt with in Induction has not only a subjective aspect but also an objective aspect. *Subjectively,* it is a state of the mind called belief, but *objectively,* it is grounded on experience. Probability is both subjective and objec- (ii) Probability is (subjective) belief based on (objective) experience

tive. Thus when we say that an event is probable, we mean that there is some evidence in favour of its happening and some evidence against its happening (objective element), and when the chances of its happening are greater than the chances of its not happening, we say, we believe that it will happen (the subjective element).

Sec. 6. Probability and Induction.

Jevons.

Generally speaking, Logicians maintain that Probability is based on Induction. But **Jevons** holds the view that Induction is based on Probability —that the conclusions of Induction are merely probable and not certain. Let us consider this view at some length.

Induction is based on Probability.

According to Jevons, Nature is so vast, and natural phenomena are so complex, that we can never be sure that the causal connection we have proved is absolutely certain. Again, Induction is based on the principle that Nature is uniform and the conclusions of Induction are true, *if* Nature is really uniform and *if* she continues to be uniform for all time. As he says: "Inductive Inference might attain to certainty, if our knowledge of the agents existing throughout the universe were complete, and if we are at the same time certain, that the same Power which created the universe will allow it to proceed without arbitrary change There is always a possibility of causes being in existence without our knowledge, and these may at any moment produce an unexpected effect" Hence the conclusions of Induction are merely probable, and Induction is based on Probability.

This view is due to the ambi-

In reply it may be pointed out that it is certainly true that on account of the complexity of natural

phenomena, it is difficult to determine a causal connection. But it is too much to say that we cannot attain certainty in any case. The objection of Jevons is based on the ambiguity in the meaning of the word, 'Certainty'. Theoretically, it is possible to say that nothing in the universe is absolutely certain. But that is not the sort of certainty we aim at in science. Hence, as **Fowler** puts it · "Many of our inductive inferences have all the certainty of which human knowledge is capable. There is no special uncertainty attaching to the truths arrived at by Induction. They are, indeed, like all other truths, relative to the present constitution of Nature and the present constitution of the human mind, but this is a limitation to which all our knowledge alike is subject, and which it is vain for us to attempt to transcend." Hence, we conclude that the view of Jevons is needlessly pedantic.

guity of the word 'certainty'

The correct view, therefore, is that Probability is based on Induction. Induction forms the objective ground of Probability, because the materials on which we base our probable conclusions are derived from experience. As **Mill** says: "We trust solely to induction from a sufficiently prolonged basis of actual observation" in all probable inferences. "If, in the run of many years, it appears that there have been in some one place four dry days for three wet, then it is a matter of inductive certainty, that in the future that proportion will hold good."

The correct view.

Sec. 7. Rules for Calculation of Chances or Estimation of Probability.

Various rules for the estimation of Probabilities have been formulated of which we notice the following :—

(1) Probability of Simple Events.

(1) *The probability of a simple event is expressed by a fraction, whose numerator is the number of favourable alternatives and denominator, the total number of alternatives.*

We have seen in Section 4 that Probability is expressed in the form of a fraction. The total number of times a die can turn up in six throws is six. This should be the denominator. As the turning up of six is one of the six possibilities, the probability of the six turning up is only once in six throws. Hence 1 is the numerator. In other words, the probability of the die turning up six is $1/6$.

(2) Probability of one or other of two events which cannot occur together.

(2) *The probability of the occurrence of one or other of two events that cannot concur is the sum of the separate probabilities.*

There are some events which from the nature of things cannot occur together. For example: in a game of dice, the faces, six and five, cannot turn up together. The question is—what is the probability of either six or five turning up? Their separate probabilities are $1/6$ each; hence, the probability of one or other happening is $1/6 + 1/6 = 1/3$.

(3) Probability of two independent events occurring together.

(3) *The probability of the concurrence of two independent events is the product of the separate probabilities.*

If an event occurs once in six times, its probability is $1/6$. If another event occurs once in three times its probability is $1/3$. Hence the probability of their occurring together is $1/6 \times 1/3 = 1/18$. Suppose that a red sky occurs once in three days and rain once in seven days, their separate probabilities are $1/3$ and $1/7$ respectively. Hence the probability of their occurring together is $1/3 \times 1/7 = 1/21$ *i.e.*, the product of their separate probabilities.

This rule may also be applied to cases of *dependent events*. If A is probably followed by B, and B is probably followed by C, then the probability that A will be followed by C may be measured by multiplying together the separate probabilities. This is illustrated in the case of *hearsay evidence*. If the probability of A's being truthful is 1/2, and the probability of B's giving a correct report of what A actually told him is 1/3, then the trustworthiness of B's evidence may be represented by the fraction 1/6.

(4) *The probability of cumulative evidence being true may be estimated by subtracting the product of the separate improbabilities from unity.* (4) Probability of cumulative evidence

For example: The probability of one witness telling the truth is 5/6 and the probability of a second witness telling the truth is 2/3. Therefore, the improbability in the first case is 1/6 and the improbability in the second case is 1/3. The product of the separate improbabilities is 1/6x1/3=1/18. Subtract the product from unity 1—1/18. Therefore, the cumulative value of the evidence, *i.e.*, the probability of the event to which they testify having actually happened is 17/18.

Sec. 8. Probable Arguments: Approximate Generalisations.

Definition

A Probable Argument may be defined as an argument, whose premises do not justify a certain but only a probable conclusion. It may have different sources, with some of which we are already familiar.

Sources of Probable Arguments —

For instance, the conclusions of *Induction per Simple Enumeration*, *Analogy*, *Unverified hypo-*

thesis, etc., are only probable and nc

(i) Simple Enumeration.

Induction per Simple Enumeratio connection is known to exist and as su sion is merely probable, the probability the number of instances observed and experience (See Ch. I, Sec. 5B, pp

(ii) Analogy.

Analogy, again, the argument is base resemblance and the probability of the pends on the number and the importanc of resemblance. (See Ch. VI, Sec. 5.

(iii) Legitimate hypothesis.

An **unverified but legitimate hypot** probable and can only attain certaint proved, thus developing into a law. Sec. 7, pp. 143-151.)

(iv) Approximate Generalisations Their nature and value in Science.

Another important source of Proba is deduction from what are called **Generalisations.** An Approximate G of the form : Most As are B. The syn word 'Most' are such expressions as ' *ally', 'usually'*, etc. In Deductive L expressions are equivalent to 'some'. Logic pays heed to the *matter* of the p hence, in cases, where certainty cann we consider the probability of a pro true. The degree of probability of a generalisation depends on the proporti number of instances which agree with, ber which conflict with, the approxin tion. In practical life, approximate are of immense help, because, though case, we are not certain that it is tru gencies of everyday life require that w some way or other. Hence, it has *Probability is the guide of Life.* It is

that proverbial sayings have an importance of their own, though, scientifically, they may often be half-truths, and therefore incorrect. For example, a merchant guides the policy of his business on the belief that 'Honesty is the best policy'; and so on. In Science, the value of Approximate Generalisations is much less. Approximate Generalisations, however, may be of *two* kinds, *viz.*, those which are definitely known to be merely probable, because, contrary instances are known to exist; or those which in the present state of knowledge are considered probable but with further extension of knowledge, may be proved to be certain. We have seen that the conclusions of Induction per Simple Enumeration may form the starting point of Scientific Induction. Similarly, Analogy may lead to the discovery of a causal connection, and then, the proposition becomes certain. Sometimes, again where exact figures are available, we may render an approximate generalisation certain, by stating exactly the exceptions. For instance, the proposition, 'Most metals are solid' is an approximate generalisation. But it was ascertained definitely by chemists that there is only one metal, which is not solid, *viz.*, the liquid metal, Mercury. When that is known, the approximate generalisation is rendered certain by mentioning the exception: 'All metals *except Mercury* are solid.'

Inferences from Approximate Generalisation are merely probable and not certain

Inferences drawn from approximate generalisations are merely probable. A certain inference can only be drawn from a universal proposition, *e.g.*, All men are mortal, No man is perfect. Take an approximate generalisation—Most gamblers are dishonest. If a particular man is a gambler, we can only draw the inference that he is *probably* dishonest. The argument

is probable, because its premise cannot justify a universal conclusion.

Sec. 9. Statistics.

We next proceed to consider in brief another method of scientific enquiry which seeks to discover some relation among phenomena in cases where the Methods of Induction fail to establish a causal connection on account of the extreme complexity of such phenomena. This method is known as the *Statistical Method*, and the branch of knowledge which employs this method is known as the science of *Statistics*.*

Definition.

Yule defines Statistics as "quantitative data affected to a marked extent by a multiplicity of causes". **Rumelin** defines Statistics as *"the results obtained in any field of reality by methods of counting"*. These definitions point out that the Statistical Method depends on enumeration or counting, and the materials of the science are "quantitative data". In Statistics, numerical facts are systematically collected, arranged, and classified for the purpose of finding some sort of relation among them.

Class of facts to which Statistics is applied.

It may be pointed out at the outset that **the class of facts to which Statistics are applied** has two principal characteristics. *Firstly*, the class of facts dealt with in Statistics is highly complex; "the data are affected by a multiplicity of causes". *Secondly*, the class of facts is also of such a nature that the laws underlying the phenomena to be investigated cannot be directly discovered. To take an example: We employ statistics to determine the death-rate of the citizens of a particular country,

* It may be noted that the word "Statistics" is used both for the science and for the raw material on which the science works *viz* the quantitative data themselves.

and for this purpose count the individual cases of death. We are unable to reduce cases of death to laws. Hence the counting of individual cases of death becomes the only means of obtaining comprehensive propositions about this fact. If, and when, such laws come to be known, there would be no further room for statistical enquiry. Thus astronomers have found laws according to which eclipses of the sun and the moon occur. From these laws, eclipses can be calculated for centuries, past and future. Hence counting of eclipses is not done in Statistics. But we do not know the general laws governing the various meteorological changes, and are not in a position to calculate accurately such changes from their conditions. Hence in Statistics, we count and collect the separate instances of changes in the weather, we count how many thunder-storms and hail-storms occur at a given place or within a given district. Thus we employ the statistical method where the class of facts is such that we do not know the general laws which govern these facts.

Uses of Statistics:

The employment of the Statistical Method has the following uses:— Uses.

(i) *Statistics describe facts precisely*: Instead of vague impressions derived from ordinary observation, statistical enumeration renders our observations exact and trustworthy, and sums up the results in a convenient form. For example, Statistics enable us to state definitely the proportion of fine days and rainy days during the year in a particular place.

(*ii*) *Statistics explain facts*. Statistics often reveal quantitative uniformities between two groups of phenomena, and thus suggest that there is some connection between them. For example: It is found that the number of births in a given country varies inversely as the price of food during the previous year. This relation of inverse variation suggests the existence of certain laws, and to that extent explains the facts.

(*iii*) *Statistics enable us to form probable conclusions*: Statistics enable us to judge what will probably be true, on the whole, of a long series of events, where we are not able to say anything definitely regarding the individual members of the series, taken separately. This is what is called the Calculations of Chances, or the Estimation of Probabilities, (See p. 249). To take an example: Suppose it is found by statistical enumeration that the annual death-rate among men of a certain age throughout the country is 20 out of every 1000. Now this may form a good working basis upon which insurance companies can proceed. Insurance companies conduct their business on the assumption that there will be an approximately constant death-rate though of course it cannot be foretold what particular individual will die in any particular year.

Misuse of Statistics.

Misuse. The great advance achieved in recent times by Statistics in different fields of knowledge have led some investigators to make extravagant claims for that science. It has been claimed that "figures cannot lie". Others have contested this claim and

have gone to the opposite extreme in saying that "figures prove nothing". It is, therefore, necessary to consider the difficulties, dangers, and limitations of Statistics and of the results obtained by the application of the statistical methods.

In the *first* place, it should be noted that "merely to count, without any definite purpose, would never help us to explain" **(Creighton).** Just as in Induction, Observation is not mere random perception but perception with a definite purpose, so in statistical enumeration we must decide what it is worthwhile collected must be properly interpreted
to count. The figures must be collected and arranged with a definite end in view, and the figures so

In the *second* place, the statistical investigator must exercise great care in collecting his data. Suppose an investigator wishes to find out how many dairy cows are there in a particular district He goes to all the farms in the district, and asks the owners how many cows they have. One farmer says that he had fifteen but had sold eight, and was waiting for the buyer to come and fetch them. Another farmer says that he had twenty A third when approached appeared vexed and gave the first figure which came to his head. It is clear that the result of such an enquiry would be to give a quite illusory figure.

Lastly, it sometimes happens that unscrupulous persons deliberately wish to mislead the public for selfish purposes by use of false figures. "From the advertisement hoarding, from the electioneering platform, from the partisan press and from a dozen other sources the man in the street is bombarded with tendentious figures put forward in support of some *ex parte* statement" **(Yule.)** This abuse of figures is responsible for popular mistrust of Statistics and

the statistical methods. This attitude, however, is not a reasonable one because a careful examination of such figures should expose the hollowness of the pretensions of the claimants. At the same time it is necessary to bear in mind that the results of statistical investigations are merely empirical generalisations, and as such they are only probable and not certain.

EXERCISE VIII.

1 What is meant by Chance? Give examples How is it eliminated?

2. Is there any such thing as Chance? Discuss the relation between *casual* and *causal* connection and indicate what is meant by calculation of probabilities.

3. Explain the relation in which Probability stands to Induction

4. What is Probable Reasoning? How would you distinguish between inductive and probable reasoning? State and illustrate the rules for the Calculation of Probabilities.

5 Distinguish between Induction and Probability What are the logical grounds of the latter? Explain and illustrate any two rules of probability by which definite conclusions may be arrived at

6. Give with examples the rules for the calculation of probabilities

7. Examine the statement that no result of inductive reasoning is absolutely certain.

8. Given two premises of the form—Most Bs are C and Most As are B—can any inference be drawn? If so of what kind, and on what conditions will its value depend?

9 Explain the following:—

(*a*) The event is probable

(*b*) The possibility of the event A is 1/6.

(*c*) The events A and B occur together by chance

(*d*) That the events A and B happen together is a coincidence

10. "Probability is belief grounded on experience" How would you estimate the Probability of the concurrence of two independent events? Give a concrete example.

11. "The probability of the occurrence of one or other of two events that cannot concur is the sum of separate probabilities" Explain the above rule, giving a concrete example

12 Distinguish between Chance and Probability and determine the place of Probability in Induction. Explain how definite conclusions can be reached by Probability.

13 According to some, the grounds of probability are [illegible] Discuss this view.

CHAPTER IX.

LAWS OF NATURE.

Sec. 1. Various meanings of the word 'Law': Laws of Nature.

The word **'Law'** is used in various senses. Originally, it meant the *command of a superior authority*, intended to be obeyed; then, it came to mean *uniform relations* obtaining among the phenomena of Nature; and yet again, it is used to mean a certain *standard*, to which we must conform in order to achieve some end or ideal

Three meanings of 'Law':—

1. *Firstly, the* word 'law' means *"an order, mandate................emanating from the will of a superior, and imposed upon a community subject to him".* It involves an obligation on the part of the members of the community to obey the laws and this obedience to the laws produces a certain uniformity in the conduct of men. In this sense, we speak of the **Laws of the State.** This is the original meaning of the word 'Law'.

1. Law means command of a superior authority.

2. *Secondly,* the word 'Law' is also used simply to mean *uniformity*. In this sense, we speak of the

2 Law means mere uniformity.

Laws of Nature **By a 'Law of Nature', we mean the uniform relations obtaining among the phenomena of Nature.** The expression 'Law of Nature' does not carry with it the idea that there is some superior authority or that any obedience is due to the laws.

Laws of State and Laws Nature compared: the former can be changed and violated, but the latter can neither be changed nor violated

Thus, the 'Laws of Nature' are called laws by analogy It came to be observed that there is a striking analogy between the regularity which prevails among natural phenomena and the uniform conduct of men who are subject to the Laws of a State The element of 'uniformity' came to be detached from the command, and the word 'Law' came to mean mere uniformity Originally, perhaps, there was an implication that the uniformity observed in Nature was due to the will of a Supreme Power ruling the universe But such an implication no longer exists In Science, 'Law' simply means uniformity This scientific attitude is well illustrated in the reply which the astronomer, Laplace (1749-1827) gave to Napoleon (1769-1821), when the emperor remarked "M. Laplace, they tell me you have written a large book (*Mecanique Celeste*—1799) on the system of the universe and have never even mentioned its Creator" The astronomer drew himself up and answered bluntly "Sire, I had no need of any such hypothesis" Science is concerned merely with phenomena and leaves it to Philosophy and Theology to deal with things which lie beyond phenomena. Hence, the word 'Law' as used in Science simply means uniformity.

THUS, THE DISTINCTION BETWEEN A LAW OF STATE AND A LAW OF NATURE is this. Laws of State are changeable and violable but the Laws of Nature are neither changeable nor violable *Laws of State are changeable*, because they are different in different countries, and in the same country, they are liable to be changed and are often changed to meet the requirements of new conditions Laws of Nature, however, cannot be changed Of course, our knowledge of a particular law may be imperfect and with the advance of knowledge, it may be found that what at one time was believed to be a law of Nature is not really so This merely means that our knowledge is liable to change A Law of Nature, however, is not subject to change Secondly, *Laws of State can be violated* but not so the Laws of Nature We can never violate the Law of Gravitation, but we can violate a particular law of the land *e g*, the Law of Crimes, the Law of Succession to property and so on

3. *Thirdly,* the word 'Law' is used to mean a *standard to which we must conform in order to attain some end* In this sense we speak of **the Laws of Logic, Laws of Ethics,** and so on Logic has for its ideal, the attainment of Truth and in order that the ideal may be realised certain rules or laws have to be obeyed. Similarly, in Ethics, we want to realise the ideal of Goodness or Virtue, and in order that we may do so, we have to observe certain rules or laws. 3 Law means a standard or ideal.

The DISTINCTION BETWEEN A LAW OF NATURE AND A LAW OF LOGIC OR ETHICS is this Law in the sense of Uniformity is *positive i e*, it states things *as they are*, whereas, Law, in the sense of a rule which must be observed in order that some end is attained, is *normative, i e*, it states things *as they should be* A Law of Nature is positive, because it states how natural phenomena actually behave The Law of Gravitation states that material bodies attract one another. But a Logical Law, *e g*, the *Dictum de omni et nullo*, states that syllogisms ought to conform and must conform to it, if they are to be true Again, Laws of Nature cannot be violated but a *Law of Logic or Ethics can be violated.*

This question has been dealt with by **Mackenzie** in his *Manual of Ethics* (pp 131-133) so satisfactorily, that it is well worth quoting the passage *in extenso* Mackenzie.

"*The Meaning of Law.*

A good deal of confusion has been caused. by *a* certain ambiguity in the word Law . .. It has been customary to distinguish two distinct senses in which it may be used We speak of the laws of a country and also of the laws of nature; but it is evident that the kinds of law referred to in these two phrases are very different The laws of a country are made by a people or by its rulers; and,

even in the case of the Medes and the Persians, there is always a possibility that they may be changed There is also always a possibility that the inhabitants of the country may disobey them, and, as a general rule, they have no application at all to the inhabitants of other countries The laws of nature, on the other hand, are constant, inviolable. and all-pervading.

There are three respects, therefore, in which different kinds of laws may be distinguished Some laws are constant: others are variable. Some are inviolable others are liable to be disobeyed Some are universal; others have only a limited application The last of these three points, however, is scarcely distinguishable from the first for what is universal is generally also constant and necessary, and *vice versa*. Consequently, it may be sufficient for the present to distinguish different kinds of laws as (1) changeable or unchangeable (2) violable or inviolable .Adopting these two principles, we might evidently have four different classes of laws—(1) Those that can be both changed and violated, (2) Those that can be changed but cannot be violated; (3) Those that can be violated but cannot be changed; (4) Those that can neither be changed nor violated.

Of the first and last of these, illustrations have already been given.

Of the second also it is not difficult to discover examples The laws of the solar system, of day and night. seedtime and harvest, and all the vicissitudes of the seasons. are inviolable so long as certain conditions last, but if these conditions were changed—say, by the cooling of the sun by the retardation of the earth's velocity, or its collision with some comet or erratic meteor—the laws also would change with them Again, most of the laws of political economy are of this character They hold good of certain types of society, and among men who are swayed by certain motives, and within these limits they are inviolable But change the conditions of society, or the characters of the men who compose it, and in many cases the laws will break down Such laws are sometimes said to be *hypothetical* They are valid only on the *supposition* that certain conditions are present and remain unchanged.

Some philosophers have thought that even the laws of mathematics may be of the above character,—that there might be a world in which two and two would be equal to

five; and that if a triangle were formed with the diameter of the earth for its base and one of the fixed stars for its apex, its three angles might not be equal to two right angles But this appears to be a mistake The laws of mathematics belong rather to the last of our four classes

The laws of Ethics, however, must on the whole be regarded as belonging to the third class They cannot be changed, but they may be violated It is true that the particular rules of morals may vary with different conditions of life, but the broad principles remain always the same, and are applicable not only to all kinds of men, but to all rational beings If a spirit were to come among us from another world, we might have no knowledge of his nature and his constitution. We might not know what would taste bitter or sweet to him, what he would judge to be hard or soft, or how he would be affected by heat or sound or colour But we should know at least that for him, as for us, the whole is greater than any one of its parts and every event has a cause; and that he, like us, must not tell lies, and must not wantonly destroy life These always are unchangeable. They can, however, be broken."

Sec. 2. Classification of Laws.

Laws have been classified according to their degrees of generality into *three* classes, *viz.*, (*i*) *Axioms;* (*ii*) *Primary* or *Ultimate Laws;* and (*iii*) *Secondary Laws.* Three classes of Laws.—

I. AXIOMS.

Axioms are real, universal, self-evident propositions. 1. Axioms are the most general laws and

(i) Axioms are *real* propositions as opposed to Verbal Propositions or Definitions.

(ii) Axioms are *universal* propositions. They are Laws of the highest generality and each of them is universally true of phenomena to which it relates.

Being the highest laws, there are no laws more general than they, in their own sphere. Some axioms are indeed more general than others. For example, the Laws of Thought—Identity, Contradiction, and Excluded Middle—possess a higher degree of generality than the Axioms of Mathematics which apply only to quantities. But the Axioms of Mathematics are the most general of laws in their own sphere

they cannot be proved though they **are the foundations of proof.**

(iii) Axioms are *self-evident* propositions, *i.e.*, each rests on its own evidence. Axioms do not require any proof, nor are they capable of any proof They are self-evident truths of so simple a character that they must be assumed to be true. Again, though they themselves cannot be proved they form the foundations of all proof. Hence, every branch of knowledge must assume the truth of some axioms which form its foundations Logic, for instance, assumes the truth of the Laws of Thought, Laws of the Uniformity of Nature and of Causation As **Carveth Read** puts it "Axioms are the upward limit of Logic, which, like all the special sciences, necessarily takes them for granted, as the starting point of all deduction and the goal of all generalisations"

2 Primary Laws are less general than Axioms but they are the most general of laws which can be proved

2 PRIMARY OR ULTIMATE LAWS.

The Laws, next in point of generality to Axioms, are the **Primary or Ultimate Laws.** The Primary or Ultimate Laws are *less general than the Axioms but they represent the highest point reached by the different sciences.* Hence, unlike Axioms, the *primary laws are subject to proof.* They are thus the most general laws which have been proved by the sciences.

The Law of Gravitation, for instance, is a primary law.

3. Secondary Laws.

Secondary Laws are less general than the Primary Laws. **Bacon** calls them "*media axiomata*" or middle axioms, because, according to him, they are steps for ascending to the higher laws. **Bain** points out that not only do the secondary laws ascend to the primary laws (*i.e.*, become more and more general and develop into higher laws), but the higher laws themselves descend into the secondary laws (or in other words, the secondary laws are deduced from the higher laws and are thereby rendered more certain). The Secondary Laws are either *Empirical* or *Derivative*.

3. Secondary Laws are less general than Primary laws.

Two sub-classes:

(1) Empirical.

(*a*) **Empirical Laws** *are those secondary laws which are presumed to be resolvable into some more general laws but which have not yet been resolved into them.* They are laws "whose *why* has not been ascertained." Thus, firstly, Empirical laws, being *secondary, are less general than the primary laws* Secondly, they are *believed to be deducible* from more general laws. Thirdly, as a matter of fact, *we have not yet been able to deduce them* from higher laws. The conclusions of the Method of Agreement are Empirical Laws. The Method of Agreement cannot prove causation but can only suggest it. It only shows that two phenomena are found together. This is an Empirical Law. We believe, however, that it is capable of being deduced from higher laws, though not yet so deduced. Thus, 'Quinine cures ague' is an empirical law. It is a uniformity established by observation It is *empirical*, because, it has not yet been deduced from any higher law.

ii) Derivative.

(*b*) **Derivative Laws** *are those secondary laws which have been deduced from the Primary Laws.* Thus, when Empirical Laws are actually deduced from Primary Laws, they become Derivative For example, the occurrence of snow on high mountains was at one time an empirical law It was observed to be true in a number of cases, but could not be deduced from higher laws It has now been resolved into the laws connected with radiant heat passing through the atmosphere Similarly, the law of terrestrial gravity or the law of the tides was an empirical law, but it subsequently became derivative, when deduced from the more general law of Gravitation.

Limited application of Secondary Laws, both

Secondary laws have a limited application. As **Bain** says: "A Derivative Law, and still more, an Empirical Law, must not be extended beyond the narrow limits of Time, Place and Circumstance" **Carveth Read** expresses the same idea by saying, that "Secondary Laws can only be trusted in 'Adjacent Cases'; that is, where the circumstances are similar to those in which the laws are known to be true"[3].

Derivative and

So far as *Derivative* Laws are concerned, they may be deduced either from a single more general law or several more general laws. When a Derivative Law is deduced from a single more general law, it will be as universally true as the single law from which it is deduced. But when it is deduced from several laws, those several laws must co-exist in a certain manner, and there should not be any counteracting agencies; for example · "That water can be pumped to about 33 feet at the sea-level, is a derivative law on this planet · is it true in Mars? That depends on whether there are in Mars bodies of a

liquid similar to our water; whether there is an atmosphere there, and how great its pressure is,. . . . .If there is no atmosphere, there can be no pumping; or if there is an atmosphere of less pressure than ours, water such as ours can only be pumped to a less height than 33 feet." (*Carveth Read*, 4th edn p. 203.)

If this be true of a derivative law, it is certainly true of an *empirical* law which has not yet been deduced from a higher law. In the case of an empirical law, the conditions are unknown and we do not know whether it results from one law or more than one. Hence, we cannot be sure that the unresolved law will be found true beyond the limits within which it has actually been found true. For example. in medical science, our knowledge is almost wholly empirical We cannot infer that two medicines of a close kind will have the same effect; thus chincona bark and quinine have not the same effect, although the former is the crude form and the latter, the essential extract.

Empirical

Note : Other classes of Secondary Laws.

A. INVARIABLE AND APPROXIMATE GENERALISATIONS

Secondary Laws may be sub-divided into (1) *Invariable Generalisations* and (2) *Approximate Generalisations*.

A Secondary Laws may be either Invariable or

Invariable Generalisations are those which are universally true, so far as experience goes. For examples: All crows are black, All material bodies fall to the earth; and so on. These are *invariable*, because the relation between the subject and the predicate is supposed to be universal.

Approximate Generalisations

Approximate Generalisations, on the other hand, are of the form: Most As are B, Most metals are solid at ordinary temperature; Most cases of plague or cholera are fatal; Most men are selfish; Most artic animals are white; and so on. The propositions are approximately general and not wholly so. *Some of these approximate generalisations are empirical laws,* because they are purely based on experience, and they have not yet been deduced from higher laws. *Some of these approximate generalisations, again, are partly empirical and partly derivative.* For example: 'Most arctic animals are white' is partly derivative, because, "this seems to be due to the advantage of concealment in the snow".

So far as Approximate Generalisations are concerned, we should attempt to explain the exceptions. When we say 'Most are', we mean 'Some are not'. Now, we should attempt to find out the reason. If we are able to discover the reason, the approximate generalisation becomes a universal proposition. The proposition "All metals *except one* (*i.e.*, Most metals) are solid" is a particular proposition, while the proposition "All metals *except Mercury* are solid" is a universal proposition.

Value of Approximate Generalisations in Science.

Approximate Generalisations are merely probable and not certain (Ch. VIII, Sec. 8, p. 253). They may sometimes be useful as a practical guide to the ordinary requirements of life, but scientifically, their value is small. In those cases, however, where on account of the complexity of phenomena, universal propositions are difficult to reach, approximate generalisations do possess scientific value. In *Politics,* for instance, there is a special advantage in true approximate generalisations amounting to "most cases"

(i) They are useful where Universal propositions cannot be reached; and further

The citizens of a particular country are so various in character, education, and conditions of life, that we cannot expect to arrive at many universal propositions, so that propositions true of the majority are sufficient for the purposes of legislation. If, for instance, fear of punishment deters most men from committing a crime, this should act as a useful guide to the statesman.

Approximate Generalisations also become useful in the domain of science, when we are able to collect *statistics*. If, for instance, it is found that 80 per cent. (most) of vaccinated persons are able to avoid an attack of small-pox in an epidemic, we can safely infer that Vaccination is a preventive of small-pox. (ii) Statistics render them highly useful

B. SECONDARY LAWS OF SUCCESSION AND OF CO-EXISTENCE.

Carveth Read points out that Secondary Laws may also be **divided** into those of Succession and those of Co-existence. Secondary Laws may be

"LAWS OF SUCCESSION are either (1) of direct causation, as that 'Water quenches fire' or (2) of the effect of a remote cause, as 'Bad harvests tend to raise the price of bread; or (3) of the joint effects of the same cause, as that 'Night follows day' (from the revolution of the earth)." Laws of Succession: or

LAWS OF CO-EXISTENCE are of several classes: (1) *Certain general laws, based on the Method of Agreement, viz.*, 'all gravitating bodies are inert' (2) *Co-existence of properties in Natural Kinds* Natural Kinds are those classes of things which agree among themselves and differ from others in numerous properties In Gold, for instance, numerous properties co-exist. (3) *Certain coincidences of qualities not essential to any kind, and sometimes prevailing amongst many different kinds, e g* White tom-cats with blue eyes are deaf. (4) Lastly, *Constancy of relative position*, as of sides and angles of a geometrical figure or of planetary orbits. Laws of Co existence

Most of these relations of Co-existence are reducible to Causation "When co-existences cannot be derived from causation, they can only be proved by collecting examples and trusting vaguely to the Uniformity of Nature. If no exceptions are found, we have an empirical law of considerable probability within the range of our exploration. If exceptions occur, we have at most an approximate generalisation, as that 'Most metals are whitish'" (*Carveth Read*).

Sec. 3. The World as System of Laws.

The World is a System of Laws:—

The World, as we conceive it, is a system of Laws. In the *first* place, there are Laws governing the different departments of Nature, and *secondly*, the different departments are not absolutely isolated from one another but are parts of one ordered and systematic whole.

(1) There are laws governing the different departments of Nature; and

The world is governed by Laws. At first Nature appears to be a chaos, in which the different phenomena are in a state of utter confusion. But careful observation shows that there is uniformity in the midst of variety, there is order in the midst of apparent confusion, or in other words, the universe is governed by laws. There is no such thing as caprice or whim or chance in any department of Nature. What appears to be Chance is nothing but ignorance of Law. For convenience of treatment in science, Nature is conceived as consisting of various departments, in each of which, there are laws which govern and control phenomena. Thus, in *Physics*, there is the Law of Gravitation, according to which all material bodies attract one another in a certain way, however various they may appear to be at first sight. In *Chemistry*, there is the Law of Definite Proportions, according to which material bodies combine

with one another, according to fixed proportions; in *Biology*, there is the Law of Heredity, according to which characteristics of the parent are inherited by the child. In *Astronomy*, there is the Law of Planetary motions, according to which planets move round the sun in an elliptic orbit, and so on. Thus every sphere of the World is governed by Laws.

Not only is the World governed by Laws, but it is a **System of Laws.** A *'System'* means a whole, each part of which has an essential relation to the whole and to all the other parts. The whole cannot exist separately from the parts nor can the parts exist separately from the whole. They are intimately bound up with one another. Thus, a System is to be distinguished from a mere *aggregate* in which there is no essential relation between the parts of which it is composed Now, though, for convenience of treatment, Nature is conceived as consisting of different departments, and though, there are different laws which govern these departments, yet the different laws are parts of one system. Nature is not a disorganised bundle of parts, but the parts are organically related to the whole. In this sense, we speak of *the Uniformity* or better still, *the Unity, of Nature.* (See Ch. II, Sec. 2, p. 72) For example, biological facts are explained in terms of chemical laws, physical phenomena are explained in terms of biological laws, and so on. There are laws of varying degrees of generality, *viz.*, Primary Laws and Secondary Laws. These secondary laws are deducible from the primary laws, and those which have not yet been deduced and are empirical, are believed to be capable of being so deduced Hence, with the progress of science, lower laws are explained by means of higher laws, these

(2) these laws are essentially connected together so as to form an ordered whole or system.

latter, again, are deduced from still higher laws, and so on, till all the various laws are found to be united with one another. Hence, we conclude that not only are there laws in the various departments of Nature, but that these laws are connected with one another into a system. Nature is a well-ordered whole, not a chaos but a cosmos.

EXERCISE IX.

1. "The problem of Logic may be summed up in two questions: How to ascertain the laws of Nature and how to follow them into their results' Explain this fully, showing the kinds of reasoning involved in these two questions, with illustrations.

2. Define and exemplify Ultimate, Secondary, Derivative and Empirical Laws, showing their relations to one another To which class those laws belong which are founded on the Method of Agreement? Give your reasons with examples.

3. Distinguish between a Law of State, a Law of Nature and a Logical Law, illustrating your meaning with examples. Science must assume that Nature is subject to law· explain why it must do so.

4 Define and illustrate Ultimate, Secondary, Derivative and Empirical Laws, explaining their relation to one another What do you understand by the expression that the World is 'a system of laws'?

5. State exactly what you understand by a Law and a Law of Nature How would you classify Laws? Mention the different methods of classifying Secondary laws that have been adopted

6. Do Laws of Nature rest on any primary assumption? How are such laws established? Explain and illustrate their different forms

7. Why should Laws of Nature be expressed as *tendencies* only?

8. What is meant by a Law of Nature? Explain Primary, Secondary and Empirical Law. Give examples.

9 What is a Law of Nature? How does it differ from an empirical law? Explain the use for science of the discovery of empirical laws

10. Explain and illustrate·—Ultimate, Derivative and Empirical Laws

11. Explain clearly the meaning of the term 'law' as employed in Natural Science What are the various kinds of laws in science? Distinguish carefully the Empirical Laws from Laws of Nature.

12 Explain what you understand by Laws of Nature. How are they classified? What precisely is meant by an Empirical Law?

13 "The phrase 'Empirical Law' contains a contradiction in terms" Explain.

14. Determine the conditions that would enable you to turn an empirical generalisation into a Law of Nature

15. How would you distinguish a Law of Nature from an Empirical Law? What does Science understand by an 'exception' to a Law of Nature?

16. Distinguish between a law of Nature and a law of the State Explain with illustrations the different kinds of Laws of Nature

17. Explain the following —

(*i*) Primary Law, (*ii*) Derivative Law, (*iii*) Empirical Law

18 Give an outline classification of the Laws of Nature.

CHAPTER X.

EXPLANATION AND ITS LIMITS.

Sec. 1. Nature of Explanation—Popular and Scientific Explanation.

Explanation means making clear something which is obscure.

The term **'Explanation'** (from *ex*—out of; and *plano*—to make plain) literally means *making plain or clear something which appears to be obscure or mysterious*. Hence, Explanation presupposes a previous state of difficulty, obscurity, or perplexity, and when we are so oppressed, Explanation affords us satisfaction, or relief "In the ordinary use of the word, 'explanation' means the satisfying of a man's understanding "

What satisfies an ordinary man may not satisfy a scientist.

The human mind has at different times been satisfied in different ways; and again, individuals vary as to the kind of explanation which affords them satisfaction. In ancient times, people conceived that all Nature was full of deities and they were satisfied with the explanation that natural phenomena were caused by supernatural agencies When a storm arose, they were satisfied with the idea that it was due to the god, Neptune In this way, natural catastrophies were attributed to the wrath of the gods. Individuals, again, vary as to the nature of expla-

nation which they consider sufficient. Superstitious people still believe in supernatural agencies, to which they attribute natural occurrences, but such explanations are not satisfactory to the scientific mind, What satisfies a rustic or the man in the street does not satisfy a scientist. Hence, though in every explanation, there is some prior difficulty or perplexity which oppresses us, and a sense of relief or satisfaction when that is removed, yet the nature of explanation, which is considered satisfactory, varies from individual to individual, and depends on the natural soundness of the man's understanding, on his education, and such other conditions.

Hence, a distinction has been drawn between **Popular and Scientific Explanation.** The distinction between them is the same as the distinction between popular knowledge and Science. Ordinary knowledge is a collection of more or less isolated facts, or at most their connections are only vaguely and imperfectly perceived, while Science attempts to bring such isolated facts under general laws, forming parts of a consistent whole. Thus · Popular and Scientific Explanation

(*i*) While Popular Explanation is satisfied with *superficial* points of similarity. Scientific Explanation seeks to determine *deep-seated* points of similarity. Points of *difference*:

(*ii*) While Popular Explanation unhesitatingly refers to *supernatural* agencies, Scientific Explanation confines itself to *natural* causes and laws. Popularly, a lunar eclipse may be explained by the supposition of a dragon's devouring the moon, but scientifically, it is explained as due to the passage of the moon through the shadow of the earth.

(*iii*) Popular Explanation is mostly concerned with explaining *particular facts*, while Scientific

Explanation is chiefly concerned with explaining *general laws.*

Even when Scientific Explanation attempts to account for a particular fact, it does not, like Popular Explanation, merely point to some one special or striking circumstance but, on the other hand, it points out the causes of the phenomenon. Popularly, as we know, applying a glowing match stick is considered sufficient explanation of a conflagration, but scientifically, it is due to all the positive and negative conditions, which constitute its cause.

Scientific Explanation, unlike Popular Explanation, is mainly concerned with the explanation of Laws. We shall see, later on, that a law is scientifically explained when it is brought under a higher law.

Sec. 2. Scientific Explanation.

Scientific Explanation. Scientific Explanation may be the explanation of an individual fact, or of law, though it is more concerned with the latter than with the former.

(1) Of an individual fact; *Scientific Explanation of an individual fact* consists in pointing out its cause,—that is in stating the law, or laws of causation, of which its production is an instance Before however, its law is discovered. we assimilate it to similar other phenomena, or in other words, we find out other things which resemble it Thus Franklin explained the phenomena of lightning by showing that it was not a peculiar fact, but was of the same kind with Electricity In other words, lightning is assimilated to Electricity Similarly, the rusting of iron is explained by pointing out its similarity with the burning of a candle In this way, points of similarity are traced, and they are found to be the effect of the same cause For instance, the rusting of iron and the burning of a candle are both due to the presence of a gas, called Oxygen, in the air.

Scientific Explanation of a Law consists in pointing out other law or laws, of which the given law is itself but a result, and from which it may be deduced. Thus the law governing the motions of the planets is explained when it was pointed out to be an instance of the more general law of Gravitation. (ii) Of a Law

Carveth Read defines Scientific Explanation as follows: **"Scientific Explanation consists in discovering, deducing and assimilating the laws of phenomena."** Definition.

We *discover* the laws of phenomena *i e.*, if the laws are not known, we start with a supposition or hypothesis as to what the cause or the law might be. Thus, *Explanation is intimately connected with* **Hypothesis.** In fact, the purpose of Hypothesis is the explanation of phenomena. The Law of Gravitation was first framed as a hypothesis to explain the fact of the falling of an apple. Explanation and Hypothesis

Explanation involves Assimilation. **Assimilation** means finding out points of similarity with other things. A thing or law is assimilated to another thing or law, when it resembles the latter in some important points Thus the Law of the tides is assimilated to the Law of falling bodies because, both of them exhibit signs of attraction. A Zebra is assimilated to a horse or a pony, because, it presents important similar characteristics. In this respect Explanation is akin to **Classification.** Scientific Classification consists in arranging objects according to "the most important and numerous points of similarity" (Ch. XII, Sec. 2). Explanation is akin to Classification, because, it is the finding of resemblance between the phenomenon in question and other phenomena. Explanation and Assimilation.

Explanation also involves Generalisation or Induction. **Generalisation or Induction** means that Explanation and Induction.

we arrive at a universal proposition on an examination of particular cases. This we can do only when the particular instances exhibit points of essential similarity, giving us a basis for the inference of a causal connection. Induction aims at the discovery and proof of a causal connection and thus affords an explanation of phenomena. Hence, Explanation and Induction are closely related. Explanation is the goal, and Induction leads to it.

Explanation and Deduction.

Lastly, Explanation involves Deduction. A Law is explained when it is shown to be deducible from some more general law. An Empirical Law, for instance, is explained when it is derived from some higher law. The law of falling bodies is explained, when it is shown to be a form of the law of Gravitation.

Sec. 3. Forms of Scientific Explanation.

Three forms of Scientific Explanation.

According to Mill, there are *three* distinct modes or ways in which Scientific Explanation of Laws may take place; *viz., Analysis, Concatenation and Subsumption.* Let us consider these three forms separately.

1 Analysis.

1. **Analysis** is a form of Explanation which consists in *resolving the law of a joint effect into the laws of its causes and the concurrence of those causes.* In simple language, Analysis means that we show that a joint effect is due to several causes acting together.

EXAMPLES:—(1) The path of a projectile is explained when we mention the separate causes, *viz*, the law of gravitation, the law of the initial force with which the projectile is thrown, the law of the resistance of air, and so on; and further we state that these separate causes act together and produce the joint effect.

(2) In explaining the orbit of a planet, we show firstly, that it results from the law of gravitation and the law that the planets tend to travel in a straight line; and secondly, those causes jointly act on the planets.

This form of Explanation is employed in the case of homogeneous intermixture of effects, in which, a joint effect is the sum of the separate effects The explanation of such a joint effect involves *two* things, viz, (i) The simpler laws of the separate effects are mentioned, and (ii) it is pointed out that they exist and act together If they do not act together, the separate effects would not be mixed and no joint effect would be produced

2. Concatenation is a form of Explanation which consists in *"the discovery of the steps of causation between a cause and its remote effects"*. In this case, the effect is shown to be due not to the supposed cause directly, but to an intermediate effect of that cause. Instead of A being shown to be the cause of C, it is found that A is the cause of B, and B is the cause of C. Thus, the connection between A and C is explained through B, the intermediate link. 2 Concatenation.

EXAMPLES (i) In lightning, it appears as if electricity has the power of creating a loud explosion; but as a matter of fact, electricity produces heat, and heat, by suddenly expanding the air, produces the loud sound. Thus heat is the intermediate link in the chain of causation.

(ii) "The maxim 'No cats no clover' is explained by assigning the intermediate steps in the following series, that the fructification of red clover depends on the visits of the humble-bees, who distribute the pollen in seeking honey; that if field-mice are numerous they destroy the humble-bees' nests, and that the destruction of field-mice depends upon the supply of cats, which, therefore, are a remote condition of the clover crop" (*Carveth Read*).

(iii) "When Chlorine was discovered, it was soon found to have a strong power of bleaching..... Inquiry showed

however that it was not really the chlorine which destroyed colour, but that oxygen is the intermediate agent. Chlorine decomposes water, and taking the hydrogen leaves the oxygen in a state of great activity and ready to destroy the colouring matter." (*Jevons—Elementary Lessons*, p 267.)

3 Subsumption.

3. Subsumption is a form of Explanation in which *a less general law is brought under a law more general.* Thus less general laws are explained by showing that they are instances of some more general law.

EXAMPLES: (i) The law of terrestrial gravitation that material bodies fall to the earth is explained by showing that it is only a case of the more general law of gravitation.

(ii) The law of magnetism is explained by bringing it under the more general law of electric currents

"This process of subsumption bears the same relation to secondary laws, that these do to particuar facts. The generalisation of many particular facts (that is, a statement of that in which they agree) is a law; and the generalisation of these laws (that is, again, a statement of that in which they agree) is a higher law; and this process, upwards or downwards, is characteristic of scientific progress The perfecting of any science consists in comprehending more and more of the facts within its province, and in showing that they all exemplify a smaller and smaller number of principles, which express their most profound resemblances." (*Carveth Read*, 4th edn. p. 303).

Sec. 4. Limits of Scientific Explanation.

Explanation is impossible, where no points of resemblance can be discovered.

Scientific Explanation, consisting, as it does, in assimilation or discovery of points of resemblance with other objects or laws, **the limits to Assimilation are the limits of Explanation.** In other words,

where we are unable to discover any points of resemblance, Explanation is impossible. Hence, the following cannot be explained:—

Hence the following cannot be explained.

(a) Fundamental states of consciousness

(a) *Fundamental States of Consciousness cannot be explained.* These fundamental or elementary states *e.g.*, Colour, Heat, Smell, Sound, Touch, Pleasure, Pain, etc , are such that they do not resemble one another but are absolutely distinct. There is, for instance, no similarity between *colour* and *heat* which will enable us to reduce the laws of colour to the laws of heat; and *vice versa.*

(b) Primary qualities of matter;

(b) *The Primary Qualities of Matter cannot be explained.* They are such qualities as extension, figure, resistance, weight, motion etc These qualities are distinct from one another and there is no resemblance amongst them, so that assimilation is impossible.

(c) Peculiarities of particular facts;

(c) *Another limit of Explanation is the infinite character of every particular fact.* However much we may know about the physical, chemical, or other laws, we can never fully explain the individual peculiarities of any particular object, whether material or mental, *e.g* , a stone or a person. We may know a good deal about the specific gravity, temperature, chemical composition, and other conditions of stones in general, but there is something in a particular piece of stone which cannot be explained. This is specially noticeable in attempting an explanation of human personality. We may know the conditions of his birth, his education, his surroundings and so on, but we can never fully explain a man's personality. The conditions are so numerous that they cannot be exhaustively enumerated.

(d) Fundamental Principles.

(*d*) *Fundamental or Ultimate Principles cannot be explained* They are laws of the highest generality. They are so general that they cannot be subsumed or brought under any law more general than they nor can they be reduced to one another. For example, the Laws of Thought, the Law of the Uniformity of Nature, etc., cannot be explained. There is nothing similar to them, and they cannot be brought under higher laws.

Sec. 5. Fallacious Explanation.

Three forms of fallacious Explanation.

Bain.

An explanation is fallacious, when it violates the conditions of Scientific Explanation. It is an explanation, only in appearance It pretends to explain facts or laws without really doing so **Bain** mentions *three* forms of Fallacious or Illusory Explanation :—

(1) *"One form of illusory explanation is to repeat the fact in different language assigning no other distinct yet parallel fact".*

(1) Mere repetition in different language;

Sometimes, in pretending to explain something, we merely repeat the fact in different language. For example, in explaining why opium produces sleep, we say it has *soporific* properties. Similarly, we say that the future must resemble the past, because, Nature is uniform Or we say—What better explanation can we give of the fact that we see through glass than that it is transparent? This is nothing but stating the same fact in different language.

(2) Regarding phenomena as simple, because familiar;

(2) *"Another illusion consists in regarding phenomena as simple because they are familiar".*

Take, for instance, the fact of the falling of an apple to the ground. This appears to be such a simple thing, but as a matter of fact, it presented great difficulties to Newton who ultimately explained it as due to gravitation.

(3) *"The greatest fallacy of all is the supposition that something is to be desired beyond the most generalised conjunction or sequences of phenomena".*

(3) To expect something more general than Ultimate Laws.

The human mind wants to attain more and more general laws. Lower laws are subsumed under higher laws, these latter, again, are brought under laws, more general; and so on. But when an ultimate law is reached, we ought to be satisfied, and this constitutes the limit of scientific explanation. But sometimes, scientists attempt to reach something more general still. Thus Newton was unable to recognise that Gravitation was an ultimate law, and he desired to discover a medium of operation, which would liken gravitation to Impact. Hitherto, such an attempt has not been successful, and it appears quite satisfactory to recognise gravitation as an ultimate law, which cannot be brought under anything higher, or which is not similar to anything else.

All popular Explanations are scientifically fallacious.

Besides the above, *all kinds of Popular Explanation are fallacious* from the scientific point of view. Hence, Explanations by superficial points of similarities, or supernatural agencies are also forms of fallacious Explanation. (For Examples, see Sec. I of this Chapter, pp. 270-271).

EXERCISE X.

1 What is meant by Explanation in science? Describe and illustrate the different forms of Scientific Explanation. Show how Explanation is related to Induction. Is it correct to say that explanation is the ideal of science?

2 (*a*) What is logical Explanation? (*b*) What are its principal forms? (*c*) What are the principal errors incidental to it? Illustrate (*b*) and (*c*)

3 What is Scientific Explanation? State and illustrate (*a*) the different forms, and (*b*) the limits of Explanation?

Explain and illustrate the chief varieties of fallacious Explanation

4 Distinguish between popular and scientific explanation Illustrate with concrete examples the different forms of the latter.

5, What do you mean by scientific explanation? What are the limits of scientific explanation?

6. Describe the nature and limits of Explanation Discuss the connexion between the scientific explanation of a phenomenon and the assignment of its cause

7. "The object of science is to explain" Discuss the statement fully Mention its three principal forms

8. Discuss what is meant by Scientific Explanation and show the relation between Explanation and Classification.

9 Explain the nature, modes and limits of *logical explanation* What is its relation to Hypothesis and Induction? Contrast the scientific conception of explanation with the popular

10 'To explain a phenomenon is to assign its cause' Discuss the statement and show how Explanation is related to (a) Induction, (b) Hypothesis, and (c) Classification

11. What is meant by logical Explanation? Indicate the limits of Explanation Give instances of illusory explanation

12 Characterise Illusory or Fallacious Explanation, and mention its different varieties.

13 Describe the nature and limits of Scientific Explanation, illustrating its different forms Give two examples of fallacious or illusory explanation.

14. Explain and illustrate Scientific and Illusory Explanation.

15 What is the precise relation of Hypothesis to Explanation? What are the different forms of Scientific Explanation? State and illustrate them Is Explanation possible in every case?

16 What are the different forms of Scientific Explanation? Illustrate the explanation of empirical laws by higher laws

17 What is Scientific Explanation? Illustrate the three modes of Scientific Explanation The explanation of nature can never be completed. Why?

18. What kind of Explanation would you offer (i) of a suicide and (ii) of the flying of an aeroplane? Show precisely how this kind of explanation differs in the two cases.

19 "To explain means to bring the particulars or the less general under the universal or the more genral." Discuss.

20. What is Scientific Explanation? Indicate the limits of Explanation. Explain the relation between Explanation and Induction.

Processes subsidiary to Induction.

We have practically come to the end of Induction, considered as a form of argument. In Chapter I, we consider the nature and the method of Induction, and its different forms In Chapters II and III, we deal with the Formal and the Material Grounds of Induction. In Chapter IV, we consider the nature and the conditions of Hypothesis, which forms the first step in Induction Chapter V deals with the Experimental Methods, which are devices for discovering and proving a causal connection Chapter VI is concerned with a weak form of Induction, known as Analogy Chapters VII and VIII respectively deal with the so-called Deductive Method and the theory of Probability, which attempt to make good to some extent the deficiencies of the Experimental Methods. Chapters IX and X deal with Laws of Nature and Scientific Explanation, which, as it were, are the results of Induction. In the three following chapters, we shall proceed to consider the nature of some processes, which are *subsidiary to* Induction. In Chapter XI, we shall consider *the Material Conditions of Definition*. In Deductive Logic, we have dealt with the conditions of Definition as a formal process. Here we shall consider its material conditions. In Chapter XII, we shall deal with *Scientific Classification* of the particular things of Nature into groups; and lastly, in Chap. XIII, we shall briefly consider the problems of *Terminology and Nomenclature*. Definition, Classification, Terminology and Nomenclature are processes subsidiary to Induction. These are not concerned with inference, but to use the language of Mill, "intellectual operations subsidiary or auxiliary to Induction".

CHAPTER XI.

MATERIAL CONDITIONS OF DEFINITION.

Sec. 1. Introductory.

In the *Textbook of Deductive Logic*, we consider the nature of Logical Definition, its conditions and limits (Ch V) We find that Definition means an explicit statement of the entire connotation of a term, that it should be distinguished from Description, that there are certain rules to which definitions should conform in order that they may be correct, and that the violation of those rules leads to certain fallacies, and lastly, the process of Definition can only be carried on within certain circumscribed limits In this chapter, we shall explain what the material conditions of Definition are

Sec. 2. Kinds of Definition.

A DEDUCTIVE AND INDUCTIVE.

A. In Inductive Definition, *we examine facts* in order to determine the meaning of a term

A distinction has been drawn between *Deductive* and *Inductive* Definitions. In **Deductive Definition,** we state the entire connotation of a term, the meaning of which is, as it were, accepted and fixed; in **Inductive Definition,** on the other hand, we attempt to determine the connotation of a term by an examination of facts. Thus, *Inductive Definition precedes Deductive Definition*. By an examination of facts we determine the meaning of a term, and when that meaning is relative-

ly fixed, we employ Deductive Definition. In the case of abstract Notions, in which examination of facts is unnecessary, we always employ Deductive Definition, *e.g.*, in Geometry and Mathematics. In Geometry, for instance, we define a 'triangle' as a plane figure bounded by three straight lines. As this is an abstract conception, there is no question of an examination of facts But in defining real things, we find that their meaning is not fixed. Hence we first proceed to determine their meaning by an examination of facts (inductive) and when our knowledge attains a certain degree of precision, we have a deductive definition. Thus, on examination, we find that men possess the essential attributes 'animality' and 'rationality'; this is inductive determination of the meaning of the term 'Man'. When the meaning is thus fixed, we define it deductively saying 'Man is a rational animal'

B REAL AND NOMINAL

B. Real Definitions refer to something really existing

A definition is *real,* when it states the connotation of something actually existing in Nature; it is *nominal,* when it states the connotation of a term, without any reference to the actual existence of the object which corresponds to it

Do we define a *thing,* or a *concept,* or a mere *name?*

Much dispute has centered round the question whether we define a *thing* or a mere *name,* or a *notion* There are *three* exclusive views on this point According to the **Realists,** we define *things;* according to the **Nominalists** we define *names only*· according to the **Conceptualists,** we define concepts or *notions* The correct view appears to be that we define *concepts which are expressed in the form of names.* Definition literally means fixing the boun-

Three views—Realism Nominal-

ism and Conceptualism.

daries *i.e.*, making something precise and exact. Now, there is no question of making *things* precise, but what is made precise is our *idea or notion of things*. Hence we define notions. These notions, however, are expressed in the form of language and names are given to them. It may further be pointed out, that most of our concepts correspond to real things, except those which are abstractions or imaginary things.

C. Substantial and Genetic Definitions.

C SUBSTANTIAL AND GENETIC.

Substantial Definitions are those which actually state the connotation of the terms defined, while the so-called **Genetic Definitions** point to the way by which their connotation can be determined Genetic Definitions are not definitions so much, as aids to the formation of definitions They indicate the mode of the origin for formation of the thing and thereby help us in understanding their nature and attributes. Thus, if we define a triangle as a plane figure bounded by three straight lines, we have a substantial definition, which states the entire connotation of the term 'triangle'. But if we say that a triangle is formed by a perpendicular plane passing through the apex of a cone, we have an example of a genetic definition. In the latter case, we do not say what a triangle is but how it is formed.

Sec. 3. Material Conditions of Definition.

Material conditions.

Definition is the statement of the connotation *i.e.*, the common and essential qualities of a term. Therefore the Material Conditions of Definition are the *rules of procedure necessary to ascertain the essential qualities of a term*. They are as follows :—

(i) We should collect for comparison the particulars coming under the notion to be defined.

(i) Positive Method—We collect particulars coming under the Notion; and

In trying to ascertain what the essential qualities are, we should collect instances of the things which go by the name, we want to define, and examine them. We find they possess some characteristics in common, while in other respects they differ. The differing characteristics are excluded. Among the common characteristics, again, some are essential, others accidental. The essential characteristics constitute the definition. This is the *positive* method.

(ii) We should collect for comparison particulars coming under the opposite notion.

(ii) Negative Method—We collect particulars coming under the opposite Notion.

In order that we may be certain that we have correctly ascertained the essential qualities, we also consider the opposite notion. This is the *negative* method. As **Bain** says: "This amounts to saying that, with the given Notion, we shall also define...the opposing Notion. As it is impossible for anything to be precisely defined, unless its opposite is known and defined with equal precision, we must in substance perform the two-fold operation, whether or not we separate the opposite aspects."

Let us apply the method to the definition of a *Solid*. By the application of the positive method, we find that the essential quality of solids is that *they resist force applied to change their form*. Then applying the negative method, and by comparing non-solids, we find that liquids and gases yield to the slightest pressure, and have no fixed form. Hence, our prior statement is confirmed.

Difficulties of conforming to the conditions.

It has been pointed out that the application of the positive and the negative methods is not so simple as it might appear, at first sight. **Firstly**, *positive*

instances are so numerous that it is not possible to collect for comparison a sufficient number of them; and even when some are collected, it is so difficult to ascertain which of the qualities are fundamental and which of them are inessential. **Secondly,** they are what are called *marginal instances,* which it is most difficult to define, because, they possess certain characteristics of one class and certain characteristics of some other class. For instance, Jelly. Is it to be treated as a solid or as a liquid?

Definition by Type.

Some Logicians have suggested that in order to obviate the above-mentioned difficulties, we should employ what is known as **Definition by Type.** A **Type** means a member of a class which possesses the characteristics of that class in a marked degree *Definition by Type consists in referring to a member of the class which possesses its characteristics in a marked degree, so that in defining the type, we define the class* Thus, a Chinaman may be said to be the type of the Mongolian race, possessing a yellow skin, a flat nose, etc Instead of enumerating the essential characteristics of the Mongolian race, we simply point to the Chinese. Or, in defining food, we select Rice or Flour as the type, possessing the characteristics of food in a conspicuous manner. Now, it is clear that this sort of definition, far from removing the difficulties, really puts the cart before the horse. How are we to know that the Type possesses the essential qualities in a marked degree, without knowing what those qualities are? Hence, the selection of the Type presupposes a knowldege of the essential qualities.

EXERCISE XI.

1 What is Genetic Definition?
2 Distinguish between Real and Nominal Definitions
3 Do we define a name or a thing?
4 Explain and criticise Definition by Type.
5 What are the Material Conditions of Definitions?

CHAPTER XII.

CLASSIFICATION.

Sec. 1. Classification.

Carveth Read defines **Classification** as **"a mental grouping of facts or phenomena according to their resemblances and differences, so as best to serve some purpose"**. This definition may be analysed as follows — Definition. Classification is

(i) *Firstly, Classification is "mental grouping"* of facts or phenomena. We classify innumerable objects which we have never seen at all. In Botany, for instance, we classify plants into groups, but all the various kinds of plants to be found in Nature are not before us, when we classify them. Hence, Classification is *mental* grouping. (i) Mental grouping of phenomena

(ii) *Secondly, things are classified, according to their resemblances and differences.* Those which resemble one another are placed under one group, and those which differ from one another are placed under different groups. (ii) according to the points of similarity.

(iii) for some purpose.

(iii) *Thirdly, Classification is made for some purpose.* We should not suppose that there is only one way of classifying phenomena. On the other hand there may be various purposes in view, and things are classified in various ways accordingly.

Purposes in Classification may be either (a) *General* or *Scientific;* or (b) *Special* or *Practical*

Purposes in Classification may be *General*, when we merely want to extend our knowledge;

The **general or scientific purpose** of Classification is knowledge. A science gives us a systematic knowledge of a particular department of Nature. In Botany, for example, we classify plants, in order that we may know their nature and their conditions. Of course, the knowledge obtained in Science may be utilised for practical purposes. But Science, as such, is directly concerned with the acquisition and extension of knowledge. We pursue knowledge for its own sake. Thus, when the purpose of classification is general or scientific, we only want to extend the bounds of knowledge. This is known as *Scientific Classification* (or *Classification for General Purposes* or *Natural Classification*).

Special, when we have some practical end in view.

In other cases, we may have a **special purpose** or object in view. Here we do not classify objects in order to acquire a general knowledge or information about them, but our aim is practical, *i.e.*, we want to have a special knowledge of them, with a special object in view. A librarian classifies books according to the alphabetical order, so that his various readers may easily reach them. This is *Classification for Special Purposes* (or *Artificial Classification*).

Sec. 2. Natural and Artificial Classification.

Two kinds of Classification:—

Logicians have recognised *two* kinds of Classification, *viz.*, Scientific or (Natural) Classification,

and Artificial Classification, according as our purpose is general or special respectively.

Scientific or Natural Classification is the mental grouping of individual objects, according to the most numerous and important points of similarity, for the purpose of acquiring general knowledge about them. It is also called **General Classification**, or **Classification for general purposes**, because our purpose is the acquisition of *general knowledge about objects.* It is called Natural Classification, because the numerous and important points of similarity which form its basis are conceived as existing in the facts of Nature, and not invented by us for some practical end.

1 Scientific or Natural Cassification (or Classification for general purposes); and

Artificial Classification, on the other hand, **is the mental grouping of facts, according to some points of similarity, selected arbitrarily, for a special purpose.** It is called **Special Classification** or **Classification for Special Purposes,** because we have some special or practical end in view. It is *artificial,* and not natural, because we ignore the fundamental points of similarity, and make some superficial points of resemblance the basis of our classification.

2 Artificial Classification (or Classification for Special purposes).

Examples.

When the physician classifies plants according to their medicinal properties, or the agriculturist classifies them on the basis of their utility as food for animals, we have instances of Artificial or Special Classification; while the botanist's classification of plants is Scientific or Natural, because, it is for the general purpose of promoting our knowledge of their origin, nature and general properties, and it is done on the basis of the most numerous and important points of similarity, observed amongst them.

The distinction is not absolute

Some Logicians take exception to the use of the terms Artificial and Natural as applied to Classification. It is, firstly, pointed out that in one sense, *all classification is artificial*, because all classification is made by us. We ourselves mentally group the objects and not that the objects of Nature are, as it were, given to us in distinct and separate groups When the scientist classifies animals, it is he who selects the points of similarity. Secondly, in another sense, *all classification is natural*, because however superficial the point of similarity which is made the basis of classification, it actually exists in the objects of Nature. Even when books are classified in a library according to the alphabetical order, the superficial similarity exists in the books, and is not made by us Hence it is difficult to draw an absolute line of demarcation between Natural and Artificial Classification, and say where 'nature' ends and 'artifice' begins This objection has considerable force from the logical point of view, but there are some good reasons for this distinction as will appear from the following sections.

Sec. 3. Natural Classification and the Doctrine of "Natural Kinds."

What is meant by "important" points of similarity?

Natural Classification is concerned with "the most numerous and important points of similarity". Mere *number* of points of similarity, if they are superficial, is of no use. The points of similarity must be "important." **Mill** explains "the most important points of similarity" as follows: The most important points of similarity are *"those which contribute most, either by themselves or by their effects, or render the things (in any class)* **like** *one another, and* **unlike** *other things (of other classes)*; which give to the class composed of them the most marked individuality; which fill as it were the largest space in their existence". Hence,

(*i*) The characteristics which are made the basis of

Natural Classification must *themselves be important qualities and*

(ii) They must be *marks of other important and numerous properties.* Thus, if, for example, the selected characteristics are *causes* of many important properties, they would form a satisfactory basis of natural classification

Natural Kinds are classes formed by Nature herself.

Mill's view of Natural Classification is intimately related to the doctrine of "Natural Kinds". **"Natural Kinds"** are classes which are found in Nature, and the individual objects belonging to them possess in common a large and indefinite number of important properties Now, Natural Classification is called, *natural*, because it simply discovers, as it were, the classification made by Nature herself. Nature herself appears to have classified objects into Natural Kinds, and in Natural Classification, we simply recognise the classes as we find them actually existing in Nature. For example, in classifying animals, we find that in Nature, there are such natural classes, as dogs, horses, etc. Dogs, *e.g.*, resemble one another in a large number of important attributes. This is different from an artificial classification of animals into, say big and small animals. The class "big animals" is not a natural kind because big animals *e.g.*, the whale and the elephant resemble each other in unimportant points such as bulk, weight, etc., while they differ from one another in important respects, such as their physical structure and conditions of life.

Doctrine of Special Creation and the theory of Evolution

This conception of Natural Kinds is based upon the theory of Special Creation as opposed to the modern **doctrine of Evolution.** According to the theory of Special Creation, God specially created one pair each of the various kinds of creatures to be found on the earth, and the Natural Kinds are groups which came into existence by descent from their first parents From this it would follow that the Natural Kinds are "fixed", and no one class can originate from

another class. The modern theory of Evolution, on the other hand, conceives the various classes as having reached their present state by evolution from a few primitive stocks It may be pointed out, however, that though the doctrine of Evolution destroys the view that in nature, classes are absolutely fixed and unchangeable, still it does not affect Natural Classification, because whatever their origin, in their present state the classes do present important and numerous points of similarity.

Sec. 4. Uses of Classification.

Uses of Classification:—

Carveth Read points out that Classification has *two* main uses, *viz.*, it helps us in understanding the facts of Nature; and that it is an aid to Memory.

(i) Classification helps Explanation.

(*i*) "*The first use of classification is the better understanding of the facts of Nature*..............; for understanding consists in perceiving and comprehending the likeness and difference of things, in assimilating and distinguishing them; and, in carrying out this process systematically, new correlations of properties are continually disclosed". Thus *Classification is akin to Explanation.* In Explanation, we notice points of similarity among the phenomena of Nature, so that we may discover their causes and laws; in Classification, also, we discover resemblances amongst natural phenomena in order that we can group them in different classes. "In both cases we have a feeling of relief. When the cause of an event is pointed out, or an object is assigned its place in a system of classes, the gaping wonder, or confusion, or perplexity, occasioned by an unintelligible thing, or a multitude of such things, is dissipated."

(ii) It is an aid to Memory.

(*ii*) Secondly, *Classification is an aid to Memory.* One of the conditions of memory is the resemblance

of a thing with something already familiar to us. So Classification by helping us to think of things in classes helps recollection.

Sec. 5. Rules of Classification.

In classifying a given number of individual facts or phenomena of Nature, we have to follow the following rules :—

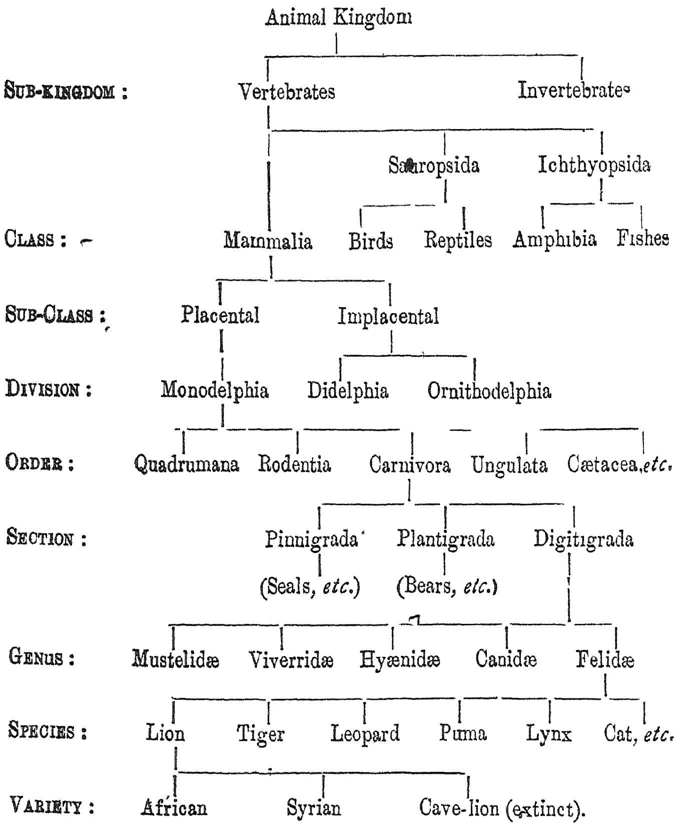
Three rules of classification.

(1) We have to group together the phenomena in classes, according to their most numerous and important points of similarity. This is the golden rule of Scientific Classification.

(2) These groups again bear important points of resemblance to other groups, and the resembling groups are connected with one another and separated from groups which differ from them.

(3) The smaller groups, again, are classified into higher groups, these latter again into still higher groups, and so on. Thus Classification should be graduated upwards.

In Classification, the term 'Variety' is regarded as the lowest class. Next in point of generality is 'Species', then 'Genera'. As the classification rises higher and higher, we have 'Tribe', 'Order', 'Sub-kingdom', 'Kingdom', in the increasing order of generality The following **Table** shows the classification of the animal kingdom :—



Sec. 6. Classification by Type or by Definition.

Is Classification by Type or by Definition?

Natural Classification is based on the most numerous and important points of similarity. It therefore, takes the help of Definition, which is a statement of the common and essential qualities of a term. According to Whewell, Classification proceeds according to Type, while Mill holds the view that Classification is based on Definition.

According to **Whewell**, *Natural Groups are constituted by Type, not by Definition*. The meaning of this simply is that individual objects are classified into Natural Groups on the basis of *mere general resemblance,* and not by resemblance in specific important qualities which are expressed in a Definition.

A Type is an eminent member of a class, i.e. an example which presents the characteristics most conspicuously and completely. According to Whewell, Natural Classes are formed by being gathered round these types. A Class really consists of the Type and all objects which bear a certain amount of general resemblance to the Type. Thus the tiger may be taken as the type of the class **"felidæ"** which according to this view, consists of the tiger and other animals resembling the tiger generally such as the cat, the leopard, the panther, the puma, etc.

Whewell's view. Classification is by Type.

According to **Mill,** *Classification should be based on Definition i.e.,* we should ascertain the essential characteristics of a class. and individual objects should be classified according as they possess these characteristics or not. Mill points out that Whewell's view is correct, in so far as a Type *suggests* to which group any given phenomenon will *probably* belong; but whether it really belongs to that group or not, depends on the question as to whether it possesses the characteristics laid down in the definition. Thus, according to Mill, Classification may be *suggested* by Type, (*i.e.,* by general resemblance) but *determined* by definition (*i e.,* the possession of essential qualities).

Mill's view. Classification may be *suggested* by Type but is *determined* by Definition

It may be pointed out that Whewell's view refers

Mill's view is more satisfactory.

to the *popular form* of Classification, while Mill's view refers to the *scientific form*. Popularly, we may be content with *general resemblance;* whether this is merely superficial or deep-seated can only be determined when we ascertain the definition which is applicable to the type as well as to the individual objects. Hence, we conclude that scientifically speaking, Mill's view is to be preferred to that of Whewell. Classification by Type helps Scientific Classification but it falls short of the latter.

Sec. 7. Classification by Series.

When a quality is present in several classes in varying degrees, we arrange the classes in a Series

In ordinary (or *lateral*) classification, we place individual facts or phenomena into groups, according to the points of resemblances and differences. If there be resemblance, we place them in the same group; if there be difference, we place them in different groups. When however we find that some classes possess a particular quality *in varying degrees,* we classify them according to a Series. *Classification by Series means the arrangement of classes of objects into a Series, according to the varying degrees in which they possess a particular quality.* **Mill** points out that the requisites of Classification by Series are *two* in number; thus,

(*i*) We bring into one grand class all kinds of things which possess a particular attribute, in whatever degree; and

(*ii*) These kinds of things are arranged in a Series, according to the degree in which they possess the quality, beginning with those which possess it in the highest degree, and terminating with those which possess it in the last degree.

Thus the classes, human beings, lower animals and plants, all possess life, but in varying degrees of complexity. We arrange these classes in a Series with 'Man' at the top, 'lower animals' next to 'man', and at the bottom of the series, 'Plants'.

Thus Classification by Series is employed in those cases, where a particular attribute is not wholly absent in any of the classes, but present in all of them, in varying degrees. Hence this form of Classification helps the employment of the Method of Concomitant Variations.

Sec. 8. Classification and Division.

Division is of a higher class into lower classes.

Logical Division is the division of a class into its sub-classes. In it, we think of an attribute, which is possessed by some members of a class and not by others, and taking this as the principle of division, we divide the higher class into its sub-classes. For example, we divide the higher class 'Animal' into its lower classes 'Man' and 'other animals'. (See *Text-book of Deductive Logic*, Ch. VI).

Classification is grouping of individuals into classes

In **Classification,** we take certain individual facts or phenomena and place them in groups, according to their points of resemblances and differences. In classifying 'men', for instance, we observe that, they possess certain important characteristics in common with the lower animals, and thus we place 'man' under the class 'animal'.

In Division we proceed from the more general to the less general, hence it is *deductive.*

Thus while, in Division, we begin with a higher class and proceed to lower classes, in Classification, we begin with individuals or lower classes and place them under higher classes. For this reason, Division is called **Deductive Classification,** while, Classification in the sense of grouping of individuals into classes

In Classification we proceed from the less general to the more general; hence it is *inductive*

is regarded as Inductive. In Division or Deductive Classification, we proceed from the more general to the less general, while in (Inductive) Classification, we proceed from the less general to the more general. In dividing the larger class 'Animal' into the smaller classes, Vertebrate and Invertebrate, we employ Logical Division; while, in grouping individual animals into classes, *e.g.*, dogs, horses, elephants, etc., we employ Classification.

Division is *formal* Classification is *material*

There is another point of distinction between Division and Classification. Division is a *formal* process, while Classification is a *material process*. In Classification, we deal with the actual concrete things of the world, while in Division, we take a logical whole, a class, which is not concrete in the sense in which individuals are concrete things. Hence it has been said that Classification deals with "the *real order*" while Division deals with "the *conceptual order*".

Fundamentally, however, the processes are the same. In both, we associate things that are alike and separate things which are unlike. The processes are not identical but they are correlative.

NOTE The word Classification' has been used by some in a generic sense as including both deductive and inductive classification Deductive classification is the same as Formal Division while Inductive Classification is what has been dealt with in this chapter.

Sec. 9. Classification and Definition.

Classification and Definition

Scientific Classification is the grouping of objects into classes according to the most numerous and important points of resemblances. In Definition, we determine what the essential qualities of things are. Hence, it is clear that Scientific Classification is based

on Definition. We can classify individuals into groups only when their essential characteristics are determined. In Artificial Classification, however, we arbitrarily select some superficial point of resemblance; hence, Definition has nothing to do with Artificial Classification.

It may further be noted that while Classification is concerned with the denotation of a term, Definition is concerned with its connotation. In Classification, we arrange *things* into classes, while in Definition, we determine their essential *attributes*. As however, things and attributes go together, Classification and Definition may be said to be correlative processes.

Sec. 10. Limits of Scientific Classification.

Scientific Classification has the following limits:— Limits:

(*i*) Classification proceeds from the less general to the more general, and hence, what is most general cannot be classified The *Summum Genus* is the highest genus, and there is no class higher or more general than it. Hence *the Summum Genus cannot be classified.* (*i*) *Summum Genus.*

(*ii*) *Marginal Cases cannot be scientifically classified.* Marginal Instances are those which possess certain characteristics of one class, and certain others of a different class. For example, *Jelly* partakes of the nature of both a solid and a liquid, and as such it is difficult to classify it. *Sponge* possesses the qualities of both an animal and a vegetable organism, and scientists had difficulty in classifying it until lately when it was found to be an acquatic animal of a low order. (*ii*) Marginal Cases.

In general it may be said that as Scientific Classification is based on Definition, *the limits of Definition* What cannot be defined

cannot be classified. *are the limits of Classification.* Those things which cannot be defined cannot be classified. Hence, if we cannot satisfactorily ascertain the characteristics of particular phenomena, they cannot be arranged in classes.

EXERCISE XII

1. Explain the nature and use of Classification. How does it differ from Logical Division? Distinguish Natural Classification from Artificial Classification and give an example of each.

2. Explain the principle of Scientific Classification.

3. Explain the nature of Scientific Classification. What does Whewell mean by classification by type?

4. Explain and illustrate (*a*) Classification by Definition, (*b*) Classification by Type and (*c*) Classification by Series.

5. What is Natural Classification? Is a Natural group determined by a Type or by a Definition? Discuss this question

6 Explain the distinction between Natural and Artificial Classification. How far is the distinction tenable? State and illustrate the principal rules for the right conduct of classification.

7 What is meant by *Natural Kind or Class*? Give an account of Natural Classification explaining what is meant by 'essential' or 'fundamental' characters as basis of classification. 'A class is nothing but the objects contained under it'—examine this statement of Mill showing whether it is correct or not

8 What is meant by the theory of Natural Kind? What modification, if any, in the scheme of Natural Classification has been effected by the theory of Evolution?

9. Explain Classification by Definition, by Type and by Series Give a concrete example of each What in this connection, is the point at issue between Mill and Whewell? Which of them do you think to be correct and why?

10 Expound the nature of Classification as distinguished from Logical Division. Point out the principal errors incidental to each, giving examples

11. 'The process of determining a Definition is inseparable from Classification' Explain this and discuss the difficulties and limits of Definition.

12. Explain the relation of Definition, Division and Classification and state with illustrations the rules for testing them

13. Explain the sense of the terms—*family, kingdom, species, variety, order* and *genus* as used in classification, giving examples of each

14 Explain and illustrate the process of Inductive classification.

CHAPTER XIII.

TERMINOLOGY AND NOMENCLATURE.

Sec. 1. Scientific Use of Names.

We are all familiar with the following lines in Shakespeare:—

"What's in a name? that which we call a rose
By any other name would smell as sweet"

Shakespare's distracted heroine in her desperation may have deluded herself into thinking that Names are things of comparative indifference, and what really matters is the person or the substance that bears the name, and that one name can freely be substituted for another. While this may be partially true of Proper Names which by themselves do not possess any meaning, so far as general names are concerned, Science demands that they should have a fixed meaning, and the substitution of one general name for another may produce nothing short of a revolution in the world of thought and make the entire science unintelligible. The importance of having a fixed name to denote a definite object or a class of objects, possessing a definite group of attributes can hardly be overestimated in Science.

Use of Names:—

The scientific use of Names may be (*i*) *indirect*, or (*ii*) *direct*. Indirectly, Names are useful as instruments of thought; and directly, Names enable us to lay down and preserve general propositions.

(*i*) *Indirect Use of Names as instruments of thought.*

(1) They are instruments of thought, and

General Names combine simpler ideas with more complex ones, and thus shorten thinking. They make

[x] By names we mean *general names*.

it possible for us to communicate those ideas more easily to others, to retain them in the mind, and to reproduce them when wanted. Take the name "civilisation". It binds up into one whole, such simple ideas as, a certain state of intellectual development, certain condition of moral feeling, certain degree of education, etc. If we had no such name, we would be compelled to enumerate all these simple ideas every time we wanted the complex idea, and it would further be difficult to remember them together. General Names perform the same function in the mind "as the binding does to the books of a library, without such, the mind would resemble a library of books, all in separate leaves, confusedly mixed".

(ii) *Direct Use of Names in laying down general propositions.*

(ii) they lay down general propositions.

The direct use of Names consists in enabling us to lay down and preserve general propositions. General Propositions enable us to avail ourselves of our past experience, and also the collective experience of mankind, by registering such experience in the form of statements. They further enable us to register laws or uniformities permanently. General Names are not merely a contrivance for economising language by doing away with the necessity of having a separate name for the infinite number of individual objects Their most important function is to register the results of our comparisons and laws Even if we had a separate name for all the various things of the world, we would not be able to register laws or the results of our comparisons without general names.

Sec. 2. Conditions of General Naming or Requisites of Scientific Language.

General Names are not only useful as instruments of thought, but their more important use consists in making it possible for us to arrive at general propositions, which register the results of comparisons and laws The question, now, is—What are the conditions which should be fulfilled in order that these general names may prove useful in the domain of Science? What are the conditions of Naming?

The same question may be put in another form. Science is concerned with the discovery and proof of general truths, and hence, scientific language requires general names for the expression of these general truths. The question arises—What are the chief requisites which are necessary in order that scientific language may serve the purpose for which it exists? What are the requisites of scientific language?

Briefly speaking, the conditions of general naming or the requisites of scientific language are *two* in number. *Firstly*, there should be a name for every important meaning, and *secondly*, every general name should have a fixed and precise meaning. Two conditions or requisites, viz,

1. Firstly, there should be a name for every important meaning.

1 There must be a name for every important meaning,

We should possess a name for every important meaning. There should not be any important meaning without a suitable name to express it. This involves that scientific language requires a Nomenclature and a Terminology.

A Nomenclature is "the system of the names of all the classes of objects, adapted to the use of each science." Thus in Chemistry, there are names 1 Nomenclature

for the various elements and their compounds; in Geology, there are names for classes of rocks and strata; in Zoology, for the various classes of animals; in Botany, there are names for the various kinds of plants; and so on.

2 Terminology. **A Terminology is a system of names for describing the parts, qualities, and activities of things.** Thus—

(*i*) There should be names for every *integral part of an object; e g.,* in animals, head, limbs, heart, nerve, tendon, etc.; in plants, stalks, leaf, stamen, pistil, etc.

(*ii*) Further there should be names for every *quality of an object; e g.,* extension, weight, solidity, impenetrability, elasticity, smoothness, etc.

(*iii*) *Lastly,* there should be names for the *processes and activities of things; e g ,* respiration, circulation, digestion, attraction, resistance, motion, etc.

Nomenclature and Terminology compared

Thus Terminology and Nomenclature both are systems of names The difference between them is that while a Nomenclature is a system of names of classes of things, a Terminology is a system of names of the parts, qualities and activities of the things which constitute the classes. In Zoology or the science of animal life, the names of the various classes of animals constitute its Nomenclature; while, the names of the various limbs of the animals, their qualities or their activities constitute its Terminology. Sometimes, however, Nomenclature and Terminology are used synonymously to mean the entire system of technical names used in a science.

2. Secondly, every general name should have a precise and fixed meaning.

II Every name should have a fixed meaning.

The second requisite of a scientific language is that every general name employed in Science should have a fixed connotation. In other words, the general names employed in Science should be free from ambiguity. Sometimes, this is secured by the use of technical names specially coined. But every science has to borrow names which are in common use. In such cases, these names should be strictly, defined. Hence Naming is intimately connected with **Definition.** Names are given to things or classes, not arbitrarily but because, they possess certain essential properties in common.

Naming and Definition.

Thus Nomenclature is intimately connected with **Classification.** The groups, whether natural or artificial, into which objects are classified cannot be remembered or communicated to others, unless they are fixed by the imposition of names A Nomenclature is a system of names of classes and sub-classes, groups of things, which constitute classification. The number of natural groups is so large that it is impossible to devise names for each of them, and even if it were possible to devise such an infinity of names, it would be impossible to remember them Thus the known kinds of plants now exceed sixty thousand, and if we take into account the sub-classes, their number would be many times that sum. Hence, some artifice is necessary by which a comparatively small number would mark off a large number of groups In some sciences, the artifice employed is what has been called the **Binary Method.** The Binary Method is a system of *double naming* employed in such sciences as Botany, Zoology, Chemistry, etc. In Botany, the scientific name of a plant consists of two words, a *substantive,* which is the name of the genus, and an *adjective,* which indicates the species. Thus the genus *Geranium* has thirteen species called Geranium phænum, Geranium nodosum, Geranium sylvatisum, etc. In Chemistry, a double name is employed

Naming and Classification.

for compounds, showing the composition of the latter; e g, compounds of the metal, Iron, are called Ferrous Oxide, Ferrous Sulphate, Ferrous Carbonate and so on.

Sec. 3. History of Variations in meaning of Words.

Variation in meaning.

Words in popular use often undergo variations in meaning, for different reasons, some of which we shall briefly consider.

(i) Accidental connotation.

(i) *Accidental Connotation.*

A frequent cause of variation in the meaning of a word is the incorporation into its meaning of some circumstance which was originally accidental. Gradually, not only is the accidental meaning incorporated into the word, but sometimes, the original meaning is obscured, even wholly superseded. Thus the word *'Pagan'* originally meant "a dweller in a village", but since such persons were usually ignorant and without enlightenment, those accidental circumstances gradually became incorporated with the meaning of the word, and it came to mean a "non-christian", a person who has not been enlightened by Christianity.

(ii) Transitive application of Words

(ii) *Transitive application of words.*

Another source of variations in meanings of words is what has been called their transitive application When men come across a new object, there is a tendency to avoid the coining of a new name and to apply to it the name of some familiar object similar to it Thus the word *'Oil'* originally meant 'olive oil' exclusively, but as new objects similar to it came to be discovered, the name 'oil' came to mean a large number of them, including such things as sulphuric acid, palm oil (a solid), with the result that its

denotation became so wide that the various things called 'oils' have very little in common with one another.

Variations in the meaning of words consist either in Generalisation, or in Specialisation or in both. **Generalisation means increasing the original denotation of the word.** For example, the word *'oil'* originally meant 'olive oil' exclusively, but now it means all the various kinds of things called 'oils'. The word *'Salt'* originally meant only 'sea-salt', but various kinds of objects resembling sea-salt, such as Potassium Nitrate (saltpetre), Calcium Carbonate (chalk), Sodium Carbonate (common soda), etc., now come under the general name 'Salt' **Specialisation means decreasing the denotation of a word.** For example, the word *'story'* originally meant a narrative whether true or false, but now it is frequently employed to mean a false narrative. Similarly *'Wit'* formerly meant intellectual power of any kind; thus, Bacon, a philosopher, Milton, a poet, Newton, a scientist were all called wits; but now it is restricted to a man who makes others laugh by a mere play upon words.

Generalisation

Specialisation.

EXERCISE XIII.

1 Fully explain and illustrate the uses of Nomenclature and Terminology. Exhibit the relation of Nomenclature to Definition and Classification.

2 What are the requisites of Scientific Language?

3 What do you understand by the Generalisation and the Specialisation of Words?

CHAPTER XIV.

INDUCTIVE AND NON-LOGICAL FALLACIES.

Sec. 1. Fallacies in Inductive Logic.

In the *Textbook of Deductive Logic*, we deal with Deductive Inferential Fallacies, which are due to the violation of the principles of the different forms of Deductive inference, and also Semi-Logical Fallacies, which arise out of the ambiguity of language In this chapter, we shall confine ourselves to the consideration of the principal kinds of Inductive Fallacies, and what are called Non-Logical or Extra-Logical Fallacies

Inductive Fallacies

Inductive Fallacies are of two kinds, *viz*, Inferential and Non-inferential The principal forms of **Non-inferential Inductive Fallacies** are, the Fallacies of *Definition, Classification, Naming*, and the Fallacies of *Observation, Hypothesis and Explanation* The principal forms of **Inferential Inductive Fallacies** are the Fallacies of *Causation, Generalisation*, and *Analogy* Thus

Inductive Fallacies
- Inferential
  - Of Causation
  - Of Generalisation
  - Of Analogy
- Non-inferential
  - Of Definition
  - Of Classification
  - Of Naming
  - Of Observation
  - Of Hypothesis
  - Of Explanation

Non-logical Fallacies are of several kinds, *viz.*, (*i*) *Petitio Principii*, (*ii*) *Ignoratio Elenchi;* (*iii*) Fallacy of Many Questions; (*iv*) *Non-Sequitur*, and (*v*) *Non causa pro causa*. Non-Logical Fallacies.

Let us first of all deal with Non-inferential Inductive Fallacies.

Sec. 2. Non-inferential Inductive Fallacies.

Inductive Fallacies may be either (*i*) inferential or (*ii*) non-inferential.

Non-inferential Inductive Fallacies are those which arise out of the violation of the rules of processes which do not form a part of inductive reasoning as such, but which are connected with or subsidiary to Induction. *Non-inferential Inductive Fallacies.*

The most important of the processes which are subsidiary to Induction are: *Material Definition, i.e.*, the process of defining terms by acquiring a knowledge of their properties; *Classification* or the process of arranging the phenomena of Nature into groups according to their resemblances; and *Naming*, or the process of formulating a system of names for groups (*Nomenclature*); or for the parts, properties, and activities of things (*Terminology*). Now, each of these processes is regulated by certain well-defined rules, which, if violated, give rise to fallacies. Hence, there are fallacies of Definition, of Classification, and of Naming.

Fallacies of Definition arise when we commit mistakes in ascertaining the essential properties of the term defined. When a tentative definition is framed, it should be examined in the light of the formal rules of Definition. (See *Textbook of Deductive Logic, Ch. V.*). (1) Of Definition.

(ii) Of Classification.

Fallacies of Scientific Classification arise when we do not classify phenomena according to the most numerous and important points of similarity. When classification is actually made in a particular case, it should be tested in the light of the rules of Division (Classification and Division are the same processes from opposite points of view; See Fallacies of Division in the *Textbook of Deductive Logic, Ch VI*)

(iii) Of Naming.

Fallacies of Nomenclature and Terminology arise when the names have no fixed meaning or when they are not otherwise efficient Names must fulfil certain general conditions in order that they may be useful in Science (Ch XIII). If they fail to fulfil those conditions, they are scientifically useless

Non-inferential Inductive fallacies may also arise out of the violation of the rules of processes which are intimately connected with inductive inference, though these processes are themselves non-inferential, *e.g.*, the process of *Observation,* the process of *framing a Hypothesis,* or the process of *Explanation.*

(iv) Non-observation and Mal-observation

Observation furnishes materials for inductive inference. It is true that Observation is often mixed up with an element of unconscious inference, but its main function is the collection of materials for inductive inference. Now **Fallacies of Observation** are of two kinds, *Non-observation* and *Mal-observation.* As these fallacies have been fully dealt with in the body of the book (See Ch. III, Sec. 4, pp. 114-117), no further treatment is necessary.

(v) Of Hypothesis

As for **Hypothesis,** it must conform to certain conditions in order that it may be used as the basis of inductive investigation. Otherwise, it is "illegitimate".

As for **Explanation,** Scientific Explanation is different from Popular Explanation. Popular Explanation is fallacious from the scientific point of view. (See Ch. X, Sec. I.)

(vi) Of Explanation

We now proceed to deal with Inferrential Inductive Fallacies.

Sec. 3. Inferential Inductive Fallacies.

Inferential Inductive Fallacies.

Inferential Inductive Fallacies arise out of the violation of the rules of Inductive inference. Inductions proper are of three different kinds, *viz*, Scientific Induction, Induction per Simple Enumeration and Analogy. In *Scientific Induction*, the inference is based on a causal connection; in *Induction per Simple Enumeration*, the inference is based on mere uncontradicted experience; while in *Analogy*, the argument is based on imperfect resemblance Each of these forms of inference has certain rules, and if we violate them, we commit fallacies Hence, Fallacies of Inductive Inference are of three main varieties, *viz*, Fallacies of Causation, Illict Generalisation, and False Analogy.

1. Fallacies of Causation.

I Fallacie Causation

Scientifically, the cause is "the invariable unconditional and immediate antecedent" or "the sum total of all conditions, positive and negative taken together". To take an imperfect or unscientific view of the cause would be to commit a Fallacy of Causation.

Fallacies of Causation arise in various ways of which we may notice the following:—

(a) Post hoc ergo propter hoc.

(a) *Post ho ergo propte hoc.*

The cause is an antecedent but any and every antecedent is not the cause. To mistake any and every antecedent as the cause of an event is to commit the fallacy of *post hoc ergo propter hoc*, which literally means—After this, therefore, on account of this This fallacy therefore consists in mistaking mere succession for true causation. This is a common error and the source of many supersti-

tions. For example, in 1910 the Halley's comet was seen and King Edward VII died. From this superstitious people argue that *the appearance of the comet is the cause of the death of the king.* This fallacy is well illustrated in the following lines from Shakespeare, in which Julius Cæsar's wife Calphurnia exhorted him not to go to the Senate, because she had dreamt bad dreams, and seen bad omens. When Julius Cæsar enquired why it should be thought that the omens referred to him, and not to other men of the world, his wife said:

"When beggars die there are no comets seen;
The heavens theselves blaze forth the death of princes"

The obvious implication is that there is a causal connection between the appearance of comets or other omens and the death of princes. In everyday life, such superstitions, which have their origin in this fallacy, are plentiful. If some misfortune occurs, it is attributed to such facts as that the man started on a journey on a Thursday afternoon, or somebody called him from behind, or somebody sneezed, or yet again, a lizard fell from the ceiling In former times, kings had in their court soothsayers, who had to interpret every dream that was dreamt, every peculiar phenomenon that was seen, and the explanation always consisted in connecting these unmeaning natural phenomena with some event in the life of the king With the advance of scientific knowledge, these superstitions are fast disappearing, but some of them have been so firmly rooted in the popular mind that even educated men are not wholly free from them.

Fallacy of mistaking one condition for the cause.

(b) **Fallacy of mistaking one condition of a phenomenon for the whole cause.**

The cause is the sum total of all the conditions taken together, but if some one condition, however prominent, is identified with the whole cause, we commit a fallacy of causation.

Examples —

(*i*) A man slips his foot on a ladder, falls and is killed. The slipping is said to be the cause of the man's death This is fallacious because other conditions such as the man's physical constitution, the height from which he fell etc, are omitted

(*ii*) A glowing match stick is brought in contact with a heap of combustible substances and *we call the application of the glowing match stick the sole cause of explosion*, neglecting to mention the nature of the substance with which the match stick came in contact.

(*iii*) Water boils at 100°C. and therefore *the boiling point of water is said to be due only to its temperature* This is wrong because water boils at 100°C. only at normal pressure at the sea-level Up a mountain the boiling point is different Therefore not only temperature but also pressure is an essential condition of the boiling point of water

(c) Fallacy of neglecting the negative condition to which a cause is subject.

Fallacy of neglecting negative conditions

Not only in a popular statement of causation but even in a scientific statement of causation, it is usual to state only the positive conditions as constituting the cause of an event. In such cases it is *assumed* that negative conditions which frustrate and counteract the effect are absent. To forget that there is such an assumption leads to a fallacy of causation.

Examples·—

(*i*) *Education does not lead to decrease of crimes because there are many criminals among educated men* This is fallacious because education is a positive condition which *tends* to decrease crimes but this tendency may be frustrated because of the presence of such negative conditions as extreme poverty, general lowering of morals in times of war etc

(*ii*) *Brilliant intellectual parts do not lead to success in life because many gifted men prove failures* This is fallacious because a brilliant intellect is certainly one of the positive conditions of success, but it may be frustrated because of such negative conditions as indolence, poverty, drunkenness, etc.

Fallacy of mistaking a remote condition for cause

(d) Fallacy of mistaking a remote condition for the cause.

The cause is an *immediate* antecedent, but sometimes we commit a fallacy of Causation by taking a remote condition as the cause of an event. Thus, it is said that *Napoleon's Russian expedition was the cause of his downfall* This one event might have proved a disaster in his career, but there were so many intervening events between that expedition and his final overthrow, that the latter would not have happened, but for various other conditions.

Fallacy of regarding co-effects as cause and effect.

(e) Fallacy of regarding the co-effects of a common cause as cause and effect.

The cause is the antecedent and the effect is the consequent. Sometimes we commit a fallacy of Causation by regarding the co-effects of a common cause as cause and effect.

Examples —

(i) *The cause of the grilling heat in summer is said to be the rise of mercury in the thermometer,* while the rise of mercury as well as oppressive heat are co-effects of the common cause *viz*, the rise of temperature

(ii) Similarly, it is wrong to suppose that *the falling of the mercury in the thermometer causes the neighbouring lake to freeze,* because they are co-effects of the same cause *viz*, fall of temperature

(iii) *The flowing tide is said to be the cause of the ebbing tide* whereas they are co-effects of the same cause *viz*, the influence of the moon.

Fallacy of confusing cause with effect

(f) Fallacy of confusing the whole or part of the cause with the effect.

For example Meteorologists are not agreed *whether the copious and sudden downfalls of rain which usually attend thunder-storms are the cause or the effect of the electric discharge* The common opinion is that they are the effect but Sir John Herschel held that they were the cause.

II Illicit Generalisation.

II. Fallacies of Generalisation or Illicit Generalisation.

In *Induction per Simple Enumeration*, we generalise on the basis of uncontradicted experience, and the value of such an induction depends on the number of positive instances we have come across and the extent of our experience. (See Ch. I, Sec. 5, pp. 31-35). But the popular mind is apt to generalise on the basis of only a few observations, confined within a limited range This leads to what is called an **Illicit Generalisation**. For example, a foreign traveller comes across only a handful of individuals and those, perhaps, belonging to a particular class, and observing them to be dishonest comes to the hasty conclusion that all men of that country are dishonest. If he is swindled by one shop-keeper, he says that shop-keepers of the place are all swindlers. Even in cases, where generalisations are arrived at on the basis of much larger experience, there is a possibility of error. For instance, people at one time thought that all swans were white, while, now, swans of other colours have been found.

The Method of Agreement cannot conclusively prove causation, and its conclusions are not certain but are merely probable Hence the generalisations arrived at as the result of an application of this method should be accepted with caution. *Empirical Generalisations* can be trusted only in adjacent cases (See Ch. IX, Sec. 2, p 262), and beyond their limited sphere, their extension is fallacious. III False Analogy.

III. False Analogy.

The fallacy of False Analogy constitutes another class of inductive inferential fallacies, and arises out of the fallacious use of the analogical argument. This has been fully treated of in Chapter VI, Sec. 6.

Sec. 4. Extra-logical or Non-logical Fallacies.

Extra-logical Fallacies

These fallacies are not due to the violation of logical rules but to the undue assumption of premises, incorrectness of the data, or misapprehension of the relation between the premises and the conclusion. We shall proceed to consider some of the important forms in which this fallacy may occur.

1. Petitio Principii.

1. Petitio Principii.

The expression *"petitio principii"* literally means *'to assume the very point proposed for debate at the outset', or "begging the question"*. Hence **"Petitio Principii" or "begging the question" is the fallacy of assuming as a premise in some form or other, either the very proposition to be proved, or a proposition which can be proved only by means of the latter.**

The simplest forms in which this fallacy occurs are the attempts to prove a proposition under the cover of synonyms, or what are called by **Bentham** *"question-begging epithets"*. For example · Opium induces sleep, because it has *soporific properties.* In this case, "soporific" means the same thing as "inducing sleep". When we condemn a Bill before an Assembly, because it is a *lawless law,* or the conduct of an individual because it is *inhuman*, we assume the very thing we set out to prove.

This fallacy sometimes assumes a complex form, when it is called *Argument in a circle* (*Circulus in demonstrando*). This occurs when the conclusion is separated by more than one step of inference from what is assumed. Thus, Plato seeks to prove the im-

mortality of the soul from its simplicity, and then again, he attempts to prove the simplicity of the soul from its immortality. Similarly, Mill attempts to prove that the Uniformity of Nature is assumed in every induction, and yet he thinks that it is the result of an Induction per Simple Enumeration. Again, the following is an example of the fallacy of arguing in a circle: We know that God exists, because the Holy Books tell us so; and what the Holy Books say must be true, because they are of divine origin.

ARISTOTLE distinguishes *five* ways in which this fallacy may occur: Five forms (Aristotle).

(i) *By assuming the very proposition which is to be proved* This is done under cover of synonyms. For example The Bill before the Assembly is calculated to elevate the character of education in the country, for the general standard of instruction in all the schools will be raised by it.

(ii) *By assuming, for the proof of a particular proposition, a universal principle which itself cannot be established except through a knowledge of that particular.* Example His cowardice may be inferred from his cruelty, for all cruel men are cowards.

(iii) *By assuming a particular to prove the universal which involves it.* This is of the nature of an Induction from Simple Enumeration. This form of the fallacy assumes that Simple Enumeration can prove a really general proposition— that because some members possess an attribute, all of them will necessarily possess it.

(iv) *By assuming successively, in parts, the proposition to be proved* This is only a special form of the first It consists in proving a general proposition by breaking it into parts, and assuming the truth of each part Thus, it is attempted to prove that "the knowledge of healing is knowledge of what is wholesome and unwholesome", by assuming it successively to be a knowledge of each.

(v) *By assuming without independent proof, a proposition which is the reciprocal of the proposition to be proved.* For example: Phillip was the father of Alexander, there-

fore, Alexander was the son of Phillip; London is north of Brighton, therefore, Brighton is south of London.

2. Ignoratio Elenchi.

Original meaning.

The expression "*Ignoratio Elenchi*" literally means "*Ignorance of the nature of the refutation*". To *refute* an assertion means to establish the exact logical contradictory of the proposition. Hence, "Ignorance of the nature of the refutation" means that we do not prove the contradictory of the statement advanced by the opponent, but something which may be mistaken for it.

Definition.

The expression, however, is now used in an extended sense. **"Ignoratio Elenchi" means the fallacy which occurs when we argue beside the point, or prove the wrong point, that is, instead of proving the required conclusion, we prove a proposition which may be mistaken for it.** It consists in "the mistaking or obscuring of the proposition really at issue, whilst proving something else instead".

Its Forms:— The fallacy of *Ignoratio Elenchi* appears in different forms of which we notice the following :—

(a) argumentum ad hominem.

(*a*) **Argumentum ad hominem.** This is a form of *Ignoratio Elenchi in which our arguments are directed to our opponent rather than to the merits of the case.* For example, supposing the question at issue is whether a particular man has committed a particular theft, and it is said that he is a habitual thief and must therefore have committed this theft also, we commit this fallacy. "This fallacy is, in fact, the great resource of those who have to support a weak case." An attorney for the defendant in a suit is said to have handed to the barrister his brief marked: 'No case; abuse the plaintiff's attorney'.

The following interesting example is quoted by **Cunningham:** "A story is told of O'Connell that on one occasion when he had to defend a man who was clearly in the wrong, the counsel for the prosecution was a certain Mr. Kiefe, who had come in for some money in a questionable way, and had taken the name of O'Kiefe. O'Connell commenced his defence by addressing his opponent:

> 'Mr. Kiefe O'Kiefe
> I see by your brief o' brief
> That you are a thief o' thief

which so disconcerted Mr. O'Kiefe and so tickled the jury that a verdict was returned for the defendant". A distinguished counsel in our country appearing for the defence having a bad case to argue began his address to the Jury by comparing the duties of the Public Prosecutor to those of a common hangman.

(b) argumentum ad populum.

(*b*) **Argumentum ad populum.** This is a form of *Ignoratio Elenchi* in which we appeal to the passion, prejudice, pity, and not to the reason. It is an "appeal to the gallery", for the purpose of exciting the feelings or arousing the passions of the crowd. It is the stock-in-trade of the mob-orator. It is the main weapon of rhetoricians and demagogues Mark Anthony's oration after the death of Julius Cæsar is the classical instance in point·

> "Friends Romans, countrymen lend me your ears;
> I come to bury Cæsar not to praise him.
>
> I speak not to disprove what Brutus spoke,
> But here I am to speak what I do know.
> You all did love him once, not without cause·
> What cause withholds you then to mourn for him?

O judgment! thou are fled to brutish beasts,
And men have lost their reason. Bear with me:
My heart is in the coffin there with Cæsar,
And I must pause till it come back to me."

A popular argument against the theory of Evolution propounded by Darwin was that its acceptance involved the acceptance of the position that our ancestors were all apes.

(c) argumentum ad ignorantiam.

(c) **Argumentum ad ignorantiam.** This is a form of *Ignoratio Elenchi* in which an attempt is made to throw the burden of disproof on the opponents. If the opponent is not able to disprove the argument, his failure is taken as its proof. It is so-called because, in it, we seek to take advantage of the ignorance of the opponent.

(d) argumentum ad verecundiam

(d) **Argumentum ad verecundiam.** This is a form of the fallacy of *Ignoratio Elenchi* in which, an appeal is made to the sentiment of veneration or a reverence for authority instead of to reason. This form of argument was most prevalent in the Middle Ages when the authority of the Church was supreme, and everything which appeared to conflict with the teachings of the Bible was condemned. Thus the theory of Evolution was condemned in its early stages because the Bible favoured the theory of Special Creation.

(e) argumentum ad baculum.

(c) **Argumentum ad baculum.** This is hardly an argument. It consists in appealing to physical force to convince an opponent. It is the argument of the wolf to the lamb. This is resorted to when arguments and diplomacy have broken down, and the point is sought to be established not by argument but by force.

3. Fallacy of Many Questions: Plures Interrogationes.

3 Many Questions.

The Fallacy of Many Questions consists in demanding "a plain answer—yes or no"—to a question which really implies an assumption For example: "Have you abandoned your intemperate habits yet?" If you say—yes, you admit that you had intemperate habits; if you say—no, it is worse still. Similarly, the questions, "Have you given up beating your mother?" "Have you left off drinking?" "It he a socialist or an anarchist? etc., are illustrations of the Fallacy of Many Questions. In all these cases, there are two questions under the cover of one, and we assume that one of them has already been asked and answered.

4. Non Sequitur or the Fallacy of the Consequent.

Non Sequitur.

The expression "*Non Sequitur*" literally means —it does not follow. It is also called *the Fallacy of the Consequent*, because in it we affirm the antecedent of a hypothetical proposition in the conclusion by affiirming its consequent in the premise. Thus:

> If it has rained, the ground is wet
> The ground is wet
> ∴ It has rained.

Thus the Fallacy of the Consequent occurs when we treat the consequent as convertible with the antecedent.

5. Non Causa Pro Causa.

5. *Non Causa Pro Causa.*

By the fallacy of "*Non Causa Pro Causa*" or "*False Cause*", Aristotle understands a fallacy which "consists in assigning as a reason for some conclusion a proposition which is really irrelevant to that conclusion". According to Aristotle, this fallacy

is illustrated in the argument of *reductio ad impossibile,* (reduction to impossibility) or indirect proof. In this we disprove a proposition, by showing that its truth leads to absurdities (reduction to impossibility) or we prove a proposition by showing that the assumption of its falsity leads to absurdities (indirect proof). Now, the fallacy of *Non Causa Pro Causa* occurs, if the absurdities do not really follow from the assumption made but from some irrelevant proposition which has been somehow or other foisted into the argument. Hence, the absurd conclusion is sought to be proved as being due to the initial assumption. The following instance is taken from **Joyce's** *Logic* (p. 281) : "Thus if we suppose the sophist's opponent to have affirmed that the death penalty for murder is just, the sophist might argue as follows: The position leads to an absurdity: for granting that the death penalty for murder is just, and that punishment is to be held just in so far as it is efficacious as a deterrent, then it would follow that it would be equally just to inflict the death penalty for pocket-picking Here the original statement has nothing to do with the conclusion obtained. This follows from the principle that the justice of a punishment is measured by its efficacy as a deterrent, —a principle which is in no way connected with the statement-that the death penalty for murder is just."

In the above sense in which Aristotle used it, the fallacy of *Non Causa Pro Causa* is not an inductive fallacy. In modern times, however, the expression has been used to mean the inductive fallacies of Causation, in which we take something which is not the cause, as the cause (See Fallacies of Causation).

Hints for working out Exercises.

In testing a given argument, it is important to bear in mind the following:—

(1) An instance given for examination is not necessarily fallacious.

(2) An argument may be fallacious in different ways For instance, the same example may be an illustration of the fallacy of Causation, or of Explanation.

(3) In every case, reasons should be assigned as to why the given argument is fallacious. Mere mentioning of the name of the fallacy is not of much importance

(4) When a fallacy has different forms, specific names of the fallacy should be given

(5) Always use the recognised technical terms in naming fallacies.

Miscellaneous Questions Answered.

I. Name and explain the precise kind of reasoning in each of the following and estimate its value :—

(a) *The sky is overcast with heavy clouds, it will therefore rain.*

Answer: This is an example of inductive reasoning, and may be said to be based on the Method of Agreement. We observe in several cases that when the sky is overcast with heavy clouds, it rains; according to the Method of Agreement, we conclude that there is causal connection between these two phenomena As the Method of Agreement is based on observation, the conclusion is merely probable, not certain.

(b) *The captain of a ship is obeyed by everybody on board the ship Therefore the Prime Minister, who is the captain of the ship of the State, ought to be obeyed by every subject of the State.*

Answer: This is a special form of analogical argument called *Analogy of Relations* (See Ch VI, Sec. 2) The argument is this· the *relation* between the captain of a ship and persons on board is *analogous* to the relation between the Prime Minister and the subjects. From this resemblance of relations, it is argued that as obedience is due in the former case, so it should be due in the latter. case The value of an argument of this description is small.

(c) *Every part of the boundary of this land is washed by the sea; it is therefore an island.*

Answer: The kind of reasoning employed here is called Colligation of facts. The navigator observing that every part of the boundary of this land is washed by the sea, colligates or binds together the set of facts observed

by him under the notion of an island. This is a process improperly called induction There is no inference in this, strictly speaking, and it may be said to be a mere description.

(d) *The three angles of this particular triangle ABC have been proved to be equal to two right angles therefore it is true of all triangles.*

Answer: The reasoning involved here is called Induction by Parity of Reasoning Something is proved of a particular diagram of a triangle and it is concluded that what is true of a particular diagram is true of all triangles which the diagram represents. This is a process which has been improperly called Induction. In fact, it is not Induction at all but Deduction. We deduce the property from the nature of triangle.

II. Analyse the following arguments, discussing their validity and pointing out the fallacies, if any :—

(a) *So far, all the men with whom I have come in contact are selfish; why should I not infer, therefore, that Man is selfish?*

Answer: The argument may be analysed as follows: So far as my own experience goes, I have only come across selfish men; I have not come across any man who is not selfish From this uniform experience, I establish the general proposition, All men are selfish. This is an example of Induction per Simple Enumeration Now, this kind of reasoning at best can be merely probable and not certain. In this case, the argument is based on extremely limited experience and as such is worthless. If the area of experience be sufficiently large I should come across selfless men also. The fallacy involved in the reasoning is called Illicit Generalisation. We seek to establish a general proposition by relying on a small number of positive instances without the establishment of a causal connection

(b) He *must be an excellent man, for I have been favourably impressed with his manner of talking*

Answer In this case we want to prove that he is an excellent man This conclusion is sought to be inferred from the circumstance that his manner of talking is impressive This argument thus involves the fallacy of *Ignoratio Elenchi*, or arguing besides the point Instead of proving the required conclusion, we prove something else and thereby seek to confuse the real issue.

III. Test the validity of the following arguments, naming the fallacy (if any), and stating reasons in each case:—

(a) *The Terror ceased immediately on the death of Robespierre, therefore Robespierre was the cause of the Terror.*

Answer: The student should have some knowledge of the history of the French Revolution in order that he may fully understand this. In the Reign of Terror during the French Revolution Robespierre as President of the Committee of Public Safety sent vast numbers of people to the guillotine but later on he himself was denounced and guillotined. After his death, the Reign of Terror ceased

The argument is that the Terror ceased immediately on the death of Robespierre and therefore he was the cause of the Terror. This argument involves the fallacy of *post hoc, ergo propter hoc* which consists in mistaking any and every antecedent as the cause. No doubt the death of Robespierre was an antecedent of the disappearance of the Terror but that was a mere accidental coincidence devoid of any causal significance.

(b) *Wine cannot be injurious to health, for if it had been so, doctors would not have prescribed it.*

Answer. The argument is that doctors sometimes prescribe wine in medicinal doses for patients suffering from certain kinds of complaints and therefore wine cannot be injurious to health under all conditions Thus this argument involves the fallacy of Illicit Generalisation in which from an examination of a limited number of cases we hastily arrive at a general conclusion, without caring to examine whether there is any causal connection or not

(c) *Women as a class have not hitherto been equal to men, therefore they are necessarily inferior to men.*

Answer. The argument may be put in this form. So far as our experience goes, we have found that women have not been equal to men. From this uncontradicted experience, we arrive at the general proposition that in all cases in future women will be inferior to men. This is a loose application of the principle of Uniformity and is an unsatisfactory illustration of Induction per Simple Enumeration The fallacy involved may be called Illicit *Generalisation*

(d) *Education is clearly the source of all discontent, since the educated not getting suitable employment are dissatisfied with their lot*

Answer The argument is that because some educated men, who are unemployed are discontented, therefore. in all cases education is the sole cause of discontent The proper conclusion should have been that unemployment is a condition of discontent It is certainly not true that all educated men are discontented though some educated

men under certain conditions may be so This is clearly an illustration of the fallacy of Illicit Generalisation, in which we pass to a general proposition on the strength of a few particular instances without the discovery and proof of a causal connection

(e) *All religions lead to God, for do not all roads lead to Rome, and all rivers fall into the sea?*

Answer: This argument is an illustration of the fallacy of False Analogy because there is no essential similarity between religions on the one hand and roads or rivers on the other. This may be considered a good simile but it has no value whatsoever as a logical argument

(f) *The flood was evidently due to the wrath of the goddess, since it began immediately after she had been slighted and it subsided as soon as she was propitiated by sacrifices.*

Answer This argument may be analysed thus The goddess is slighted and immediately after the flood began, and again the goddess is propitiated by sacrifices and at once the flood subsided Hence, it appears that something happens and something else follows and again, something is removed and something else disappears. Thus these two cases appear to be illustrations of the application of the Method of Difference but as a matter of fact these arguments are fallacious because the instances have been secured by observation and the Method of Difference does not yield correct conclusions unless the instances are secured by experiment. Thus these arguments involve the fallacy of *post hoc, ergo propter hoc* in which any and every antecedent is mistaken for the cause.

(g) *The University is the Temple of learning, and therefore Politics has no place in it.*

Answer This argument involves the fallacy of *ignoratio elenchi* because the conclusion is wholly irrelevant The description of the University as the "Temple' of Learning is calculated to produce the sentiment of veneration or reverence and the argument appears to be that Politics in which there may be diplomacy and strife of parties is not a fit subject for a *Temple* of Learning. This irrelevant argument may be said to be an instance of *argumentum ad verecundiam*, which is a special form of the fallacy of *ignoratio elenchi*

IV. Is causal connection between A and X validly disproved (a) if the absence of A is followed by the presence of X, and (b) if the presence of A is followed by the absence of X?

Answer: (a) A is absent in the antecedents but X is present in the consequents; *e.g.*,

BCD followed by XYZ

The question is whether we can say that there cannot be a causal connection between A and X. The answer is that in the case where A is actually absent but X is present, there cannot be any causal connection between the two. But according to the doctrine of the Plurality of Causes, though in this case A is not the cause of X, there may be other cases in which X may be produced by A.

(b) A is present in the antecedents but X is absent in the consequents; *e.g.*,

ABC followed by MNO

The question is whether it is proved that there is no causal connection between A and X. The answer is: No, because in the symbolical example given above B may be a negative condition which frustrates the production of the effect X.

EXERCISES WITH HINTS.

1. Explain the form of the reasoning, deductive and inductive or both, implied in the following propositions, indicating the premises or conclusions left unexpressed, and estimating the value of the reasoning:—

(*a*) *The Sun will rise to-morrow morning.*

[HINTS: So far as experience goes, we see that the Sun rises every day. This is Induction per Simple Enumeration. Supplying the suppressed major premise 'What rises every day will rise to-morrow', we conclude that the sun will rise to-morrow, by Deduction. Simple Enumeration can only yield probable conclusions.]

(*b*) *The lower animals feel pain just as we do.*

[HINTS: This is an Analogical argument. If 'pain' means 'physical pain', the conclusion is highly probable, because lower animals resemble men in important points regarding physical structure; if however 'pain' means 'mental pain', it is a False Analogy because the mind of lower animals is essentially different from the mind of man.]

(*c*) *He will die within a few hours, he has been bitten by a cobra.*

[HINTS: Supplying the unexpressed major premise 'all men who are bitten by cobra die within a few hours', we conclude by Deduction that this man will die. The major premise however is an undue assumption. Hence we commit the fallacy of undue assumption of premise.]

(*d*) *The inner world of mind attains the light of knowledge through seven organs of sense; therefore some mediaeval astronomers said, there must be seven planetary bodies to illuminate the outer world of nature.*

[HINTS: This is an illustration of False Analogy due to an improper use of metaphorical language Figuratively, knowledge may be compared to light. But to argue from this that the number of the sources of light in the outer world of nature would be the same as number of the sources of light (knowledge) in the inner world amounts to an improper use of metaphor.]

(e) *The Factory Commissioners say in their report: The past and present conditions of work in factories are undoubtedly calculated to cause physical deterioration; and we are here struck by the marked absence of elderly men among the operatives!*

[HINTS: The argument is that the marked absence of elderly men among the operatives in factories is due to the physical deterioration of the operatives. This may be one of the conditions but cannot be said to be the whole cause Hence this involves a fallacy of Causation, mistaking a condition for the whole cause.]

2. (a) 'An eclipse of the Sun would occur when the moon intervenes between the earth and the sun; an eclipse of the sun would occur when some great calamity is impending over mankind; examine the logical ground and comparative validity of the above two propositions.

[HINTS: (i) We observe on several occasions that a solar eclipse occurs when the moon intervenes between the earth and the sun. By the Method of Agreement we conclude that such intervention is the cause of solar eclipse. This conclusion is highly probable because this is an instance of what has been called a Natural Experiment (p. 122), (ii) The second proposition involves the fallacy of *post hoc ergo propter hoc*]

(b) *'All arsenic is poisonous'; the substance before me is arsenic, it is therefore poisonous, explain the logical process underlying (i) your belief in the major premise, (ii) your belief in the minor premise and (iii) in the conclusion drawn.*

[HINTS: (i) Major premise—result of Induction, (ii) Minor premise—Observation. (iii) Conclusion—Deduction.]

3. (a) What kind of logic is applied by (i) the engineer when he is designing a new bridge, (ii) the physician when he is prescribing a particular medicine to a patient, and (iii) the legislator when he is introducing a new law? Give reasons for your answer.

[HINTS. (i) Deductive, if the new bridge is of similar type as other bridges; it involves an application of the principles of engineering to this new case Also inductive, if it presents new features (ii) Deductive, application of the established laws of medicine to the particular case;

also inductive, if peculiarities are observed. (iii) Both deductive and inductive: he accepts established principles but modifies them according to the circumstances of the case.]

(b) *'A house without tenants, a city without inhabitants present to our minds the same idea as a planet without life, a universe without inhabitants' The conclusion here evidently is that the planets and stars are inhabited What is the logical form of the inference? State it in its simplest form What do you consider to be its logical value and why?*

[HINTS This is a False Analogy, because the points of similarity between a house and a city on the one hand and planets and stars on the other hand, are unimportant points.]

(c) *'I have noticed' says Meng Tsein, 'that in years of plenty many good actions are done, and in years of scarcity many bad actions are done.' What is the inference evidently implied here? Express it in its simplest form showing under which of the logical methods it falls. and indicate its logical value as inference.*

[HINTS The conclusion implied is that scarcity is the cause of bad actions. The method employed here is the Joint Method of Agreement and Difference The argument being based on mere observation is only probable and not certain.]

(d) *'We think, as civilisation advances, poetry almost necessarily declines. Therefore, though we fervently admire those great works of imagination which have appeared in dark ages, we do not admire them the more because they have appeared in dark ages' State in full logical form the reasoning involved, and test it fully.*

[HINTS: This is a quotation from Macaulay's Essay on Milton A relation of concomitant variation is sought to be established between the advance of civilization and the decline of poetry, the implied conclusion is that want of civilisation is the cause, and good poetry is the effect. As this is a case of Concomitant Variations as applied in observation, and that. within a limited field, the conclusion is merely probable.]

(e) *'The more the number of pools of stagnant water in a district is reduced, the rarer does the occurrence of malarial fever become' What conclusion can be drawn from the above statement? State the reason implied in its full logical form exhibiting the logical method applied in it and estimate the logical value of the inference*

[HINTS: The conclusion drawn is that stagnant pools are the cause of malarial fever. The Method employed is the Method of Concomitant Variations. The conclusion is merely probable because the premises have been supplied by observation.]

4. (a) Galileo saw with his telescope that the planet Jupiter is a centre about which several satellites revolve receiving light and warmth from him; and appealed to this fact as an argument to prove that the Sun is a centre about which the Earth and other planets revolve as satellites. What was the logical character of Galileo's reasoning here, and what, in your opinion, was its logical value?

[HINTS. Analogical argument: conclusion probable.]

(b) *You believe that Siraj-ud-dulah took Calcutta from the English in 1756, State on what grounds you believe this proposition,and exhibit their logical character.*

[HINTS Authority]

(c) *It is a popular belief that there will be a change of weather at new moon: What logical process would be required to establish the validity of this belief.*

[HINTS. The Method of Agreement or the Joint Method.]

(d) *'Every man who has seen the world knows that nothing is so useless as a general maxim' Estimate this logically, pointing out what would be necessary for logically establishing this proposition.*

[HINTS General maxims and proverbs are arrived at by Induction per Simple Enumeration They are merely probable.]

5. (a) Water freezes to-day at 52 degrees Farenheit; therefore it will freeze at 32 degrees at this time next year: explain the logical character and value of this.

[HINTS This is correct, if conditions are the same. Otherwise it is a case of Illicit generalisation—an empirical law cannot be extended beyond its sphere.]

(b) *It is a common hypothesis in Bengal that railway embankments are causes (proximate or remote) of malarial fever, what logical processes would be required to prove or refute this hypothesis?*

[HINTS· The Method of Agreement or the Joint Method]

(c) *Yesterday the smoke of chimneys tended to sink downwards, and it rained in the afternoon. Can any connection be inferred from this?*

[HINTS Fallacy of Causation, co-effects being mistaken for cause and effect "Sinking of smoke" is not the cause of rain but they are both co-effects of the same cause *viz*, lowering of the atmospheric pressure because the atmosphere was charged with plenty of vapour]

(d) *When Crusoe saw the print of a bare foot on the sandy shore he thought at once that savages had landed on his island Give a logical analysis of Crusoe's thought.*

[HINTS Framing of Hypothesis]

6. **Test the following:**

(a) *The people of England are wealthy because they are industrious.*

[HINTS: A causal connection is assumed to exist between Industry and acquisition of wealth, hence this involves the fallacy of undue assumption of premise.]

(b) *As soon as I sat down to study this morning, the man in the adjoining room began to play on the harmonium. He must, therefore, be a very malicious person.*

[HINTS: "Malice" cannot be inferred from one instance—it may be a chance coincidence.]

(c) *This patent medicine must be very efficacious; for all the testimonials speak of the marvellous cures effected by it*

[HINTS Fallacy of Non-observation of Instances. Instances where the medicine proved a failure are overlooked pp. 115--116.]

(d) *We ought not to go to war, because it is wrong to shed blood.*

[HINTS The premise 'it is wrong to shed blood' is false, because under certain circumstances e g, for resisting an invading army, shedding blood may not be wrong. Hence this involves the fallacy of undue assumption of premise. Carveth Read regards this as an instance of *Circulus in demonstrando.*]

7. **Test the following:**

(a) *Since it is just to take interest, it is right to exact it from one's own father*

[HINTS: The Fallacy of Accident, because here the argument passes from a simple statement to a statement under a certain condition, for taking interest may be just but taking it forcibly (exacting) from one's father is not just.]

(b) *A nation must ultimately perish, because it is an organism and all organisms grow old and die.*

[HINTS False Analogy, p. 228.]

(c) *We see the sun rise and set every day, therefore, the sun does actually rise and set.*

[HINTS *Mal-Observation*, p. 117.]

(d) *Unhealthiness in the parents is not the cause of unhealthiness in the children, because many unhealthy persons have perfectly healthy children*

[HINTS We observe that in many cases, unhealthy parents have healthy children To conclude from this that bad health of parents does not affect the health of children is to commit a fallacy of causation in which we neglect negative conditions Bad health of parents *tends* to produce bad health in children in *the absence of*

negative conditions, *e g*, good food, care in bringing them up in healthy environment, etc.]

8. Test the following:

(a) *The great famine in Ireland began in 1845 and reached its climax in 1848 During this time agrarian crime increased very rapidly until in 1848 it was more than three times as great as in 1845. After this time it decreased with the return of better crops until in 1851 it was only 50 per cent more than it was in 1845. It is evident from this that a close relation of cause and effect exists between famine and agrarian crime*

[HINTS: An instance of the application of the Method of Concomitant Variations in Observation]

(b) *So far my experience goes, A has been invariably preceded by B I, therefore, conclude that B is the cause of A.*

[HINTS Induction per Simple Enumeration; conclusion merely probable.]

(c) *A habitual drunkard who studied hard for the army in his youth has got shattered nerves, therefore the cause of his shattered nerves is his hard study in youth*

[HINTS Fallacy of Causation—a remote condition is taken to be the cause—while the immediate condition, *viz*, habitual drinking, is left out of account.]

9. Test the following:

(a) *'Steel, when brought to white heat in the fire, must be plunged into cold water in order to obtain the requisite temper Similarly the human body after the steam-bath, on being cooled down, becomes strong and hardy."*

[HINTS· False Analogy]

(b) *The human soul must be diffused over the whole body because it animates every part.*

[HINTS· False Analogy, because the soul is compared to a material object occupying space. The soul may animate every part without being diffused (*i e*, physically present) in every part]

(c) *What would our ancestors say to this, Sir? How does this measure tally with their institutions? How does it agree with their experience? Are we to put the wisdom of yesterday in competition with the wisdom of centuries? (Hear! Hear!) Is beardless youth to show no respect for the decisions of mature age? (Loud cries of hear! hear!) If this measure be right, would it have been reserved for these modern and degenerate times?'*

[HINTS *Ignoratio Elenchi—argumentum ad verecundiam and argumentum ad populum—petitio principii.*

10. Test the following:

(a) *Punishment must have some other and higher justification than the prevention of crime. for if punish-*

ments were only for the sake of example, it would be indifferent whether we punished the innocent or the guilty, since the punishment, considered as an example, is equally efficacious in either case.

[HINTS. This argument involves the fallacy of the Falsity of premise because the premise 'it would be indifferent whether we punished the innocent or the guilty' is not true. The latter part of the argument involves the fallacy of *petitio principii* for the proposition 'the punishment considered as an example is equally efficacious in either case', and the proposition 'if punishment were only for the sake of example, it would be indifferent whether we punished the innocent or the guilty' have the same meaning though expressed in different words.]

(b) *Moisture bedews a cold metal or stone when we breathe on it. The same appears on a glass of ice-water, and on the inside of windows when sudden rain or hail chills the external air. Therefore, when an object contracts dew, it is colder than the surrounding air.*

[HINTS. The Method of Agreement—conclusion probable.]

(c) *With various kinds of polished metals no dew is deposited; but with various kinds of highly polished glass dew is deposited. Therefore the deposit of dew is affected by the kinds of substances exposed.*

[HINTS: The Joint Method of Agreement and Difference. Different kinds of highly polished glass are present and there is deposit of dew; again different kinds of polished metals are present (glass is absent) there is no deposit of dew. The conclusion is that dew is deposited on glass but not on metals. It should be noted that the two sets of instances also differ in respect of the degree of polish; metals are polished while glasses are *highly polished.* Hence the deposit of dew may as well be due to the high degree of polish. Hence the conclusion is not valid.]

11. Test the following:—

(a) *We should think it a sin and a shame if a great steamer, dashing across the ocean, were not brought to a stop at a signal of distress from a mere smack.. .And yet a miner is entombed alive, a painter falls from a scaffold, a brakesman is crushed in coupling cars, a merchant falls ill and dies and organized socety leaves widow and child to bitter want or degrading alms.*

[HINTS: *Argumentum ad populum.*]

(b) *Nobody can be healthy without exercise, neither Natural Body nor Body Politic; and certainly, to a Kingdom or State, a just and honourable war is the true exercise A Civil war, indeed, is like the heat of a fever, but a foreign*

war is like the heat of exercise and serves to keep the Body in health.

[HINTS: False Analogy]

(c) *During the retreat of the Ten Thousand a cutting north wind blew in the faces of the soldiers, sacrifices were offered to gods and the severity of the wind immediately ceased,*

[HINTS: *Post hoc, ergo propter hoc.*]

(d) *It is known by direct experiment that for any given degree of temperature only a limited amount of water can remain suspended as vapour, and this quantity grows less and less as the temperature diminishes Therefore, if there is already as much vapour suspended as the air will contain at its existing temperature, any lowering of temperature will cause necessarily a portion of the vapour to be condensed as dew,*

[HINTS: This is a fallacious application of the Method of Concomitant Variations because this method has no application beyond facts which have been actually observed. (P 187)]

12. Examine the following:—

(a) *The Great War was followed by an outbreak of epidemic diseases therefore, the war may be taken to be the cause of the diseases*

[HINTS: *Post hoc, ergo propter hoc*]

(b) *The number of deaths in Calcutta per annum is greater than in Nagpur Therefore Calcutta is more unhealthy than Nagpur*

[HINTS Fallacy of Non-observation because the greater population of Calcutta may be the cause of greater mortality]

(c) *One of the sailors rescued wore an amulet, and this was, no doubt, the cause of his escape*

[HINTS Carveth Read regards this as a fallacy of causation in which co-existent phenomena are mistaken for cause and effect, it is better to regard it as an illustration of the fallacy of *post hoc, ergo propter hoc.*]

13. Test the following:—

(a) *This man must be a thief, for he was in the room whence the article had been stolen and he came out as soon as I entered the room.*

[HINTS. *Post hoc ergo propter hoc* (P 177)]

(b) *How glad am I at your success, which I really anticipated! Is it not meet, therefore, that you should give me some reward?*

[HINTS: *Ignoratio Elenchi*]

(c) *Is not dirt washed away by a current of water? Yes, Then, is it impossible that all the sins of omission and commission may be washed away by the holy water of the Ganges when one dips into it? No Thus it matters little how one acts or thinks so long as he periodically bathes in the Ganges.*

[HINTS: False Analogy.]

14. Examine the following:—

(a) *The non-co-operators should not boycott the University for their leaders are all educated men.*

[HINTS: *Ignoratio Elenchi.*]

(b) *The Reforms have given a death-blow to Bolshevism in India, for the people are now looking forward to a better state of things.*

(c) *Life is but light, and no wonder that a man should be cut off in the prime of life, a light burning is very often put out by a puff of wind.*

[HINTS False Analogy.]

(d) *We should not mourn the death of eminent men, for by the law of the survival of the fittest, those that are still alive must be fitter and better than those that are gone.*

[HINTS: The fallacy of accident.]

(e) *Oh, I would give the whole world for peace of mind for that is really invaluable.*

[HINTS: *Petitio Principii.*]

(f) *I do not consult physicians for those that do so also die*

[HINTS: We observe that in some cases, persons consult physicians and yet die From this we conclude that physicians cannot cure *in any case*. This is Illicit Generalisation.]

15. Test the following:—

(a) *Green colour is found only on the surface region of plants If one cuts across a living twig or into cactus body, the green colour will be seen only in the outer part of the section Hence, the green colour of plants holds some necessary relation to light.*

[HINTS: The Joint Method of Agreement and Difference. Conclusion probable]

(b) *Tyndall found that of twenty-seven sterilized flasks containing infusion of organic matter and opened in pure Alpine air, not one showed putrefaction, while of twenty-three similar flasks, opened in a hayloft, only two remained free from putrefaction after three days He concluded that putrefaction is due to floating particles in the air.*

[HINTS: We observe several instances in which floating particles are present (when flasks are opened in a hayloft), and putrefaction is present; we also observe several instances in which floating particles are not present (because the flasks are sterilised) and putrefaction is not present By the Joint Method of Agreement and Difference, we conclude that floating particles are the cause of putrefaction The conclusion is highly probable because the instances have been secured with great care This may also be taken as an illustration of the Method of Concomitant Variations because floating particles cannot be wholly eliminated from air, while air is more or less free from floating particles The argument then would be—the more the floating parti-

cles in the air, the greater the putrefaction; the less the floating particles, the less the putrefaction. The conclusion is highly probable, because the instances have been carefully secured.]

16. Examine the following:—

(a) *All bats are birds, for they have wings.*

[HINTS. The suppressed major premise, All winged creatures are birds, is an undue assumption.]

(b) *The anatomical resemblance between men and apes is marvellous, and from such resemblance we can safely conclude that men are descended from apes.*

[HINTS: False Analogy.]

(c) *The Professor must be a very learned man for his words are so big and hard that very few understand them.*

[HINTS: *Non Sequitur.*]

17. Test the validity of the following inductive arguments, giving reasons, and name the experimental method by which each is established:—

(a) *As soon as I came to this place my disease was cured. Threfore, the climate of this place effected the cure of my disease.*

[HINTS: This is an instance of the application of the Method of Difference. As the instances have been secured by observation, the conclusion is probable but not certain.]

(b) *The only cause of the diminution of crimes is the abundance of food supply, for crimes increase with the growing scarcity of food-stuff.*

[HINTS: The Method of Concomitant Variations. The greater the scarcity, the greater the number of crimes. From this we conclude that scarcity is the cause of crimes. As the instances are secured by observation, the conclusion that scarcity is one of the conditions of crimes is probable. The conclusion drawn here however is that the abundance of food supply is the *only* cause of diminution of crimes. This is a fallacy of causation in which one condition is mistaken for the whole cause.]

18. Test the validity of the following inductive arguments, giving reasons, and naming the method by which each is established:—

(a) *Cold applied to water in an iron vessel freezes it. Cold applied to cocoanut oil in a glass bottle freezes it. Therefore Cold is the cause of freezing.*

[HINTS: The Method of Agreement.]

(b) *If, on a clear night a sheet or other covering be stretched a foot or two above the earth, so as to screen the ground below from the open sky, dew will be found around the screen but not beneath it. The open sky must, therefore, be an indispensable antecedent of dew.*

[HINTS: The Method of Difference.]

(c) *Water is jointly conveyed into a tank by three pipes of unequal size at the rate of ten gallons per minute. It is*

known that the first two pipes together admit water at the rate of seven gallons per minute. Threfore, the amount of water admitted by the third pipe is at the rate of three gallons per minute

[HINTS. The Method of Residues]

(d) *The retention of an idea in memory becomes more tenacious with the frequency of its repetition and the increased attention we pay to it The retention of an idea in memory depends, therefore, on attention and repetition.*

[HINTS· The Method of Concomitant Variations.]

19. Test the following:—

(a) *About twenty of the children who went to the picnic caught cold There were more than a hundred on the grounds, and all ate at a common table and played pretty much the same games. It was discovered, however, that those who caught cold had stolen off to wade in a chilly creek.*

[HINTS· Those twenty children who stole off to wade in a chilly creek differed from the other children only in one point, their eating and playing being exactly the same. The result was that they caught cold (while the others did not) According to the Method of Difference, wading in a chilly creek is the cause of catching cold. As the instances have been secured by observation, the conclusion is merely probable The probability, however, is of a high degree because this phenomenon was observed to be true of all the twenty children who had stolen off to wade in a chilly creek]

20. Test the following argument, naming the fallacies if any, or stating the experimental method employed, as the case may be:—

(a) *In the last two Intermediate examinations the percentage of passes in Logic has been considerably lower than that in other subjcts. The teachers of Logic in the colleges must therefore, be incompetent.*

[HINTS If new teachers are appointed and students are unsuccessful (other conditions being more or less the same), the inefficiency of the new teachers may be the cause of the failures of students But from observation we can never be certain that other conditions are the same. It may be that the new students are of inferior intellectual calibre or they are unmindful of their studies, or there were political disturbances or the questions set in the examination were unusually stiff Hence the argument involves the fallacy of Non-observation of essential circumstances]

(b) *During the Great War trade was very brisk and all business men made large profits Since the end of the War there has been depression in trade, and business men have suffered heavy losses. It is clear, therefore, that peace is unfavourable to commercial prosperity.*

[HINTS: The Method of Difference There is War, and trade is brisk War ends, and brisk trade ends (there is depression). We conclude that War is the cause of brisk trade As the instances are secured by Observation, we cannot be certain that other circumstances are the same. Henre the conclusion is not certain Besides the conclusion drawn is 'Peace is unfavourable to trade' This is what has been called Material Obversion and is fallacious This involves the fallacy of non-observation of such essential circumstances as stable conditions, sense of security etc which in peace may be favourable to trade]

(c) *Pasteur disproved spontaneous generation by two instances of equally fermentable substances, one in a closed air-tight vessel, the other exposed, both under identical conditions The result, positive and negative, corresponded to the exposure and non-exposure, thus showing that the germs had been imported through the air*

[HINTS The Method of Difference]

(d) *No dew is deposited on a piece of metal which has been polished, but on the same metal unpolished, dew is deposited copiously Therefore, the deposit of dew is affected by the kind of substances themselves.*

[HINTS The Method of Difference]

(e) *England is the richest country in the world and has a gold currency Russia and India are poor countries and have little or no gold currency Therefore, a cold currency is the cause of a nation's wealth*

[HINTS: The Joint Method of Agreement and Difference As the instances are secured by observation, the conclusion is not certain]

21. Test the following arguments, naming the fallacies, if any, or stating the experimental method employed, as the case may be:—

(a) *The proportion of inmates in ouru lunatic asylums who can read and write is very high, from which we may infer that education is one of the causes of insanity*

[HINTS: There are various fallacies here Firstly, "men who can read and write" and "educated men" are not the same Secondly, it is an undue assumption of premise because the premise may not be true at all Thirdly, to argue that because some (a large proportion—not all) insane persons are educated, therefore education is a cause of insanity is to commit the fallacy of Illicit Generalisation, mistaking a *casual coincidence for a causal connection*]

(b) *The great famine in Ireland began in 1845 and reached its climax in 1848 During this time agrarian crime increased very rapidly until in 1848 it was more than three times as great as in 1845. After this time it decreased with the return of better crops until in 1851 it was only 50 per*

cent. more than what it was in 1845 It is evident from this that a close relation of cause and effect exists between famine and agrarian crime.

[HINTS. The Method of Concomitant Variations. As the instances are secured by observation, the conclusion is merely probable.]

(c) *The armament firms thrive on war, the glaziers gain by broken windows; the operating surgeons depend on cancer for their children's bread. Therefore, fortune is everywhere made out of destruction, waste, and disease.*

[HINTS. The Method of Agreement.]

(d) *The nearer all bodies approach the earth, the greater is the velocity with which they approach it, but the farther they are, the less is the force with which they tend to approach it, we may therefore infer that their greater (or less) nearness to the earth is the cause of their increased (or diminished) velocity.*

[HINTS: The Method of Concomitant Variations]

(e) *The principal cause of awakening in the country is the spread of Western ideas through the Western system of education. The awakening is more conspicuous in British India than it is in the Native States; and in British India itself provinces that have imbibed the spirit of Western education more are more progressive than others. Looking to the development of political consciousness in the country as a whole, we find it has run parallel to the development of Western education.*

[HINTS: The Method of Concomitant Variations. The greater the Western education, the greater the political consciousness]

22. Test the following arguments, naming the fallacies, if any, or stating the experimental method employed, as the case may be:—

(a) *Sir D. Brewster (Scottish Scientist, 1781—1868) proved that the colours seen upon mother-of-pearl are not caused by the nature of the substance, but by the form of the surface He took impression of mother-of-pearl in wax, and found that though the substance was entirely different, the colours were exactly the same.*

[HINTS Brewster put wax on the surface of several substances and took impressions on the waxed surface He found in several instances that whenever the form of the surface was the same, the colours were the same By the application of the Method of Agreement, he concluded that the form of the surface is the cause. The conclusion is highly probable]

(b) *The place of a planet at a given time is calculated by the law of gravitation, if it is half a second wrong, the fault is in the instrument, the observer, the clock or the law Now, the more observations are made, the more of*

this fault is brought home to the instrument, the observer, and the clock.

[HINTS: The Method of Residues.]

(c) *A community consists of individuals, and an individual consists of cells. Both of them are complex structures. The individual grows, and so does the community. The community thrives when members co-operate with one another, and the health of the individual is dependent on the organs working in harmony. There being such close resemblance between the individual and the community, it is obvious that the community, like the individual, is mortal.*

[HINTS False Analogy.]

(d) *It has been observed that as education spreads, the number of crimes becomes less. People therefore advocate universal compulsory education on the ground that thus crime will disappear. But yet we see that criminals belong to the educated classes, and that the majority of uneducated persons are not criminals.*

[HINTS We observe a number of cases and find that as education spreads, the number of crimes becomes less. By the Method of Concomitant Variations, we conclude that education is the cause or at least a condition of diminution of crimes. As the instances are secured by observation, the conclusion is merely probable. It would be improper to think that if education be universal, crimes will wholly disappear because human nature being what it is, crimes will not wholly disappear. We also observe that some educated men are criminals. From these observations the correct conclusion is that Education is a condition of the diminution of crimes. To think that Education is the cause of disappearance of crimes is to mistake a condition for the whole cause.]

23. Test the following arguments, naming the fallacies, if any, or stating the experimental method employed, as the case may be:—

(a) *It is ridiculous to suppose that the world can be flat; for a flat world would be infinite and an infinite world could not be circumnavigated.*

[HINTS This means (i) if the world be infinite, it could not be circumnavigated. The world has been circumnavigated. Therefore, the world is not infinite; (ii) a flat world would be infinite. The world is not infinite. Therefore, the world is not flat. The truth of the conclusion depends on the truth of the premise 'A flat world would be infinite' but this premise appears to be unduly assumed.]

(b) *Like the shark the whale is a vertebrate. Both are large marine animals, have wide mouths and feed only on living animal nutriment. Both are flesh-like in form*

and have no hairy covering. Therefore, like the shark, the whale also breathes oxygen dissolved in the water and has no need to be supplied with atmospheric air.

[HINTS This is an analogical argument. The points of similarity, particularly the point that both are marine animals, appear to be essential points, and as such, the cnclusion is probable But 'Analogy' never gives certainty.]

(c) *All scientific statements should be capable of proof. But it is impossible to prove everything, for that would involve an infinite regress Hence science is impossible.*

[HINTS: This argument involves the fallacy of Ambibuity The word 'Proof' is ambiguous. Every branch of knowledge is based on certain presuppositions which are not proved, but which are taken for granted. Science is no exception. But on the basis of these suppositions, other facts can be proved.]

(d) *Conciousness is unaccountable on a purely physical or mechanical theory of the world. Hence, instead of attempting to explain consciousness in terms of physical law. we must find in physical law a manifestation of intelligence.*

[HINTS: This is the fallacy of 'Arguing beside the point' It may be that Consciousness cannot be explained in physical terms, but from this the converse does not follow viz. physical laws can be explained in terms of conciousness]

(e) *Epilepsy appears in animals born of parents which were rendered epileptic by an injury to the spinal cord. Hence acquired characters are transmitted to the offspring.*

[HINTS This conclusion is arrived at by the application of the Method of Agreement on an observation of several instances where acquired characteristics are transmitted. The conclusion is merely probable.]

(f) *The faster I run, the hotter I get. Therefore running makes a man hot.*

[HINTS Concomitant Variations.]

24. Test the following arguments and discuss the methods employed:—

(a) *There is no such thing as colour inhering in external bodies, because colours are more or less vivid in proportion to the light, and if there be no light, then no colours are percieved.*

[HINTS: The argument is this: The greater the light, the more vivid the colour, the less the light, the less vivid is the colour According to the Method of Concomitant Variations, the conclusion is that Light is the cause or a condition of Colour Next Light is removed, and Colour disappears This is an application of the Method of Difference. The conclusion is correct if it is held that Light is a condition of Colour but the conclusion which appears

to have been drawn is that Light is the sole cause, which is wrong This is the fallacy of mistaking a condition for the sole cause]

(b) *Everything that grows must also decay Hence the British Empire must also fall by the hand of time.*

[HINTS If "everything" includes "British Empire", the conclusion is arrived at by deduction (syllogism) and is formally valid But if "everything" means "every individual organism" then an analogy is sought to be drawn between it and the British Empire. This would be a False Analogy; because a community and an individual present many essential points of difference]

(c) *The earth cannot be round, for it were, the water in the Suez Canal would flow out at both ends.*

[HINTS: If the earth were round, water would flow out. Water in the canal does not flow out. Therefore, the earth is not round This is quite correct as a hypothetical-categorical syllogism, but the major premise appears to have been unduly assumed]

(d) *The low money price of goods is not a proof of poverty, for China is a richer country than any part of Europe and yet Gold has a higher purchasing power in China than in Europe.*

[HINTS 'Gold has a high purchasing power in China' means that price of goods in terms of gold is low in China. In spite of that China is rich Therefore, a country may be rich and yet the price of goods in terms of gold there may be low. In other words, low price of goods in terms of gold is not a proof of poverty This is correct but the conclusion drawn here is that the low "money" price of goods is not proof of poverty. The fallacy is to confuse gold with "money". Gold is only one species of money.]

(e) *The object of war is durable peace; therefore soldiers are the best peacemakers.*

[HINTS: This argument involves the fallacy of *petitio principii*, because it is assumed in the premise that the object of war is peace, and in the conclusion, the same idea is expressed by saying that those engaged in war have the same object There is also an ambiguity in the world 'peace'. The premise may mean that after war, peace comes The conclusion appears to be that soldiers are actually engaged in peacemaking which is obviously wrong]

(f) *Fermentation is caused by some foreign agent; for, grape juice passed into a vacuum barometer tube remains free from fermentation for any length of time.*

[HINTS: This is an illustration of the Method of Difference In one instance, grape juice is exposed to air; and fermentation occurs. In another instance, air is removed (vacuum is produced), fermentation disappears]

(g) *Colonies are like fruits which drop off from the tree when ripe.*

[HINTS: False Analogy.]

25. Test the following arguments and discuss the methods employed:—

(a) *The fall of the mercury in the thermometer is followed by the freezing of the lake, and is therefore its cause.*

[HINTS: Fallacy of Causation because the co-effects are mistaken for cause and effect. See p. 314.]

(b) *Charles I was a good judge of paintings and indulgent to his wife. The English people, therefore, acted wrongly in revolting against him.*

[HINTS: *Ignoratio Elenchi*, because the conclusion is wholy irrelevant Charles I might have had private virtues but the English people denounced him as a bad King.]

(c) *Victory depends on superiority in shooting, for by superior archery the Parthians checked the Romans, Tiberius overcame Arminius, the Turks, established thier empire and the English defeated the French.*

[HINTS: The Method of Agreement.]

(d) *The usefulness of their colouration to animals is shown by the fact that colour and making are constant in each species of wild animals while there is great variation in colour among domestic animals*

[HINTS: The Joint Method of Agreement and Difference.]

(e) *The sense of smell in flies and cockroaches is connected with the antennæ, for they can no longer find carrion if the antennæ are cut off.*

[HINTS: The Method of Difference]

(f) *Lack of education is the cause of crime, for the increase in education in the last fifty years have been accompanied by a decrease in crime.*

[HINTS: The Method of Concomitant Variation As the instances are secured by observation, the conclusion is merely probable]

26. Test the following arguments and discuss the methods employed:—

(a) *A comet was seen shortly before the outbreak of the war. If was therefore, if not the cause of the war, at least a heavenly messenger to proclaim its approach*

HINTS: *Post hoc ergo propter hoc* Also Fallacious Explanation because it refers to supernatural agencies]

(b) *There has been an increase in the number of convictions for crime There has therefore been an increase in criminality.*

[HINTS: Non-observation of essential circumstances (P. 116)]

(c) *The sun must move round the earth, for we have seen it rise and set.*

[HINTS: Mal-observation. (P. 117).]

(d) *The dull colours of most female birds are due to protective colouration, for during incubation they are liable to attack. The female birds which have bright colours nest in holes in the ground or in trees in a way that completely conceals the sitting bird.*

[HINTS: The argument appears to be as follows: We observe that most female birds have dull colour. We also observe that those birds which have bright colours conceal themselves during incubation. From this we conclude that Nature has given dull colours to most female birds for their protection. This is a fallacy of causation which Carveth Read calls the fallacy of transcendent inference. Causation as understood in Inductive Logic does not concern itself with what Aristotle calls the final cause. See p. 89.]

27. Test the following arguments and discuss methods employed:—

(a) *The war-leaders of U.S.A., Italy, Germany, and Great Britain have been replaced by new leaders, hence Stalin will also be replaced.*

[HINTS: We appear to observe in four cases that war-leaders have been replaced by new leaders. According to the Method of Agreement, we conclude that this will occur in all cases including Russia. This argument is fallacious firstly because there is the fallacy of malobservation in collecting instances. In U.S.A., President Roosevelt died, and President Truman succeeded all during the war, and not after the war. Then the war-leaders of Italy and Germany met with death after the defeat of those countries. Only in Great Britain, Churchill was replaced by Attelee after the war. So really there is only one instance. The conclusion drawn by the application of Agreement is therefore unwarranted. This is an instance of Illicit Generalisation.

This argument may also be taken as an illustration of False Analogy. The points of difference between England and Russia are so numerous and so vital that we cannot by Analogy argue that what happened in England will happen in Russia.]

(b) *The excision of the thyroid gland dulls the intellect, hence the thyroid gland is the cause of our intelligence.*

[HINTS: See P. 214 Item 34.]

(c) *A showman announced that children of both sexes were admitted free and then charged for admission to boys and girls on the plea that neither of them were children of both sexes.*

Logical form: Children of both sexes will be admitted free. Boys and girls are not children of both

sexes therefore Boys and girls will not be admitted free.

This argument involves the Fallacy of Composition because here we proceed from the distributive to the collective use of the term "Children of both sexes"]

(d) *Paris did nothing wrong in carrying off Helen with her consent, for her father left her free to choose her husband.*

[HINTS: *Textbook of Deductive Logic*, p. 333]

(e) *All punishment is degrading, for if it is justified, the offender is a brute, if it is not justified, the brutality is in the person who inflicts it.*

[HINTS: Materially false dilemma—see *Textbook of Deductive Logic*]

(f) *As the fury of the storm increased, the pilot increased the speed of the plane, hence the storm is the cause of the aeroplane's speed.*

[HINTS. We observe that as the fury of the storm increased, the pilot increased the speed of the plane According to the Method of Concomitant Variation, we conclude that the "storm" is the cause of "the speed of the plane". The correct conclusion should have been that increase of the fury of the storm is the cause and the pilot's driving the plane at a greater speed is the effect. To say that "storm" is the cause of "speed of the plane" is mistaking a remote condition for the cause because the pilot apprehends danger and increased the speed—not that the speed increased directly because of the storm]

(g) *The fittest survive; hence those who have survived the war are the best.*

Logical form: All who are fittest are persons who survive; therefore, All who survive are fittest.

This involves an improper Simple Conversion of an A proposition. See Textbook of Deductive Logic.

28. Test the following and discuss the methods employed:—

(a) *A, B, C and D live in their respective flats on the same premises, A occupying the topmost flat and D the ground floor flat. It is known to B, C, and D that A is in the habit of throwing all sorts of rubbish on the lower flats. One day C quarrels with D over a matter. After some time D sees from inside his room some rubbish fall down on his yard. Now D concludes that it is C who has thrown the rubbish to harrass him.*

[HINTS: The argument appears to be this: There was a quarrel between C and D After this rubbish falls on D's yard D concludes that C has thrown the rubbish. This argument involves the fallacy of *post hoc ergo propter hoc*. It may also be noted that in this case D has an

unconscious *bias* against C The subjective condition of impartiality is absent and this vitiates observation—see p 114]

(b) *A child was suffering from some pimples on its face The father gave it a dose of "Arnica" (homœopathic medicine) and the mother made it take a sufficient quantity of butter-milk for some days. And the pimples healed up. Now both the mother and the father claimed full credit for the cure.*

[HINTS. Either the father's "Arnica" or the mother's "butter-milk" or both together is the cause of the cure. As both medicines were administered (assuming other things are equal) it is impossible to determine their separate effects in this case. In order to ascertain the real cause, separate experiments should be made in cases of other persons suffering from pimples If in one case it be found that "Arnica" is administered, the patient is cured—other things remaining the same—then according to the Method of Difference, it will be proved that Arnica cured pimples.]

(c) *Hari buys a plot of land which is said to be haunted. After some time his son dies Hari is now firmly convinced that the buying of that plot of land is the cause of his son's death*

[HINTS: This involves the fallacy of *post hoc ergo propter hoc.*]

(d) *A and B are travelling in the same tramcar and are sitting side by side After some time A gets down. Now B finds that his money bag is missing B concludes that A must have stolen his bag and slipped away*

[HINTS A gets down B finds his bag missing Hence B concludes that A is the thief In this case the Method of Difference has been applied, the instances being secured by observation Hence, the conclusion is not certain. It cannot be definitely said that everything else remained the same]

(e) *A certain football team is always found to win when it is captained by Mr X, although other players frequently change The team was defeated on several occasions when Mr X was absent It is therefore concluded that Mr. X's presence is the cause of the team's success.*

[HINTS Joint Method of Agreement and Difference. See p 172 Concrete Example (b)]

(f) *Vaccination is believed to be a protection against small pox But in times of epidemic, vaccinated people are sometimes found to die of small pox Therefore vaccination is of doubtful value.*

[HINTS We observe several instances and find that when a person is vaccinated, he does not suffer from small pox. According to the Method of Agreement, we conclude that vaccination is protection against small pox In times

of epidemic, contrary instances are found. The result is that the general proposition sought to be established by the Method of Agreement is disproved.]

29. Test the following and discuss the Methods employed, if there be any:—

(a) *In an instrument there are an iron ring and an iron ball, such that the ball can pass through the ring. Now the ball is heated to the highest degree. It is now found that the ball does not pass through the ring. Heat, therefore, must have expanded the ball.*

[HINTS: In this case, there is an iron ring and an iron ball passes through the ring Heat is applied to the ball and then the ball does not pass through the ring. According to the Method of Difference, we conclude that heat has expanded the ball As the instances have been secured by Experiment, the conclusion is certain.]

(b) *Ram often suffers from cold in winter. He finds that he catches cold invariably if he goes out for a walk in the morning, and that he does not catch cold if he keeps indoors*

[HINTS The Joint Method of Agreement and Difference The conclusion is probable, not certain because the two sets of instances, positive and negative, have been secured by Observation]

(c) *A number of persons died from snake-bite. Therefore snakes are poisonous.*

[HINTS: The Method of Agreement. The conclusion is not certain because the instances have been secured by Observation Moreover, this Observation is confined within a very limited area because if more instances are observed, it will be found that persons do not always die from snake-bite Hence this argument involves Illicit Generalisation.]

30. Test the following and discuss the Methods employed, if any:—

(a) *A bell struck in vacuo gives no sound. Therefore air is the medium of sound.*

[HINTS: The Method of Difference See p. 176]

(b) *A body expands more and more as it is heated more and more Therefore heat is the cause of expansion.*

[HINTS: The Method of Concomitant Variations.]

(c) *Both mosquitoes and cases of Malaria have, in some parts of Bengal, become much rarer after the swamps of the areas have been filled up. Therefore mosquitoes are the cause of malaria*

[HINTS: See p. 207.]

(d) *Once an athlete weighed on his chest a load of 30 maunds of steel. A person who witnessed the performance concluded that the athlete was a great magician.*

[Hints: The witness starts with a pre-conceived notion that such a fact is impossible. This is an illustration of Fallacious Explanation.]

(e) *As the temperature of the body increases the mercury in the thermometer rises. Heat is therefore the cause of the expansion of the mercury.*

[Hints: The Method of Concomitant Variations. See p. 184.]

(f) *Rabi is a fickle-minded boy. One day when he was walking by the river-side near his house he perceived a snake at a distance in front of him. He, however, gathered courage and stepped forward to look more closely. He found to his surprise that there was no snake, but only a piece of rope.*

[Hints: Fallacy of Mal-observation in the first instance. On closer examination, the fallacy is detected.]

31. Test the validity of the following inferences, showing the reasons and naming the Experimental methods used, if any:—

(a) *Iron balls have been found to break glass panes when they strike against the latter, therefore, "being made of iron" is the cause of breakage of glass panes.*

[Hints: The Method of Agreement.]

(b) *This man, shot through the heart, drops down dead; therefore, shooting through the heart causes death in all cases.*

[Hints: P. 176, concrete example (b).]

(c) *The weight of the load is the total weight less the weight of the cart.*

[Hints: P. 188, concrete example (i).]

(d) *Cocoanut trees best flourish in places near the sea.*

[Hints: The Method of Agreement.]

(e) *The temperature rises to the highest degree when the sun is at midsky, therefore, the sun is the cause of the earth's heat.*

[Hints: The Method of Concomitant Variations. Conclusion probable because instances have been secured by observation.]

(f) *The malarial fever stopped with the administration of quinine for two days, therefore, quinine cures malaria.*

[Hints: The Method of Difference.]

(g) *Telegrams are ominous, for they bring the news of the death of some friend or relative.*

[Hints: The argument is the result of an Induction by Simple Enumeration. The range of observation is extremely limited. If we observe more cases, we shall find that Telegrams also bring good news. Hence this is an instance of Illicit Generalisation.]

32. Examine the following, and mention the names of the Experimental Methods, if any, such are involved:—

(a) *Other circumstances remaining the same, a gust of wind took away a paper from my table Therefore, whenever a paper is taken away from my table this is due to a gust of wind.*

[HINTS: The correct conclusion is: In this case, the gust of wind is the cause of the blowing away of the paper. This is established by the application of the Method of Difference. But the Method of Difference does not prove that this is the cause in all cases See p. 180.]

(b) *If some pacts have been violated by a country it will always violate pacts*

[HINTS: The argument is this We have observed several instances in which a particular country has violated pacts We have not observed any instance to the contrary By Induction per Simple Enumeration, we conclude that the said country will always violate pacts The conclusion is probable, not certain]

(c) *Before the British quitted India there had been for a long time non-violent agitation against them. Therefore, the independence of this country is the result of that agitation.*

[HINTS: Mistaking one condition of a phenomenon for the whole cause. See p 312]

(d) *The Americans are a great nation In order to be great, therefore, we should also wear trousers like them, eat more protein, popularise co-education, banish religion from politics, follow their law of inheritance and even attune our national anthem to their orchestra.*

[HINTS: False Analogy See p 228]

(e) *The Bihar Earthquake was due to our ill treatment towards Harijans.*

[HINTS. Popular or Fallacious Explanation See p. 271.]

(f) *"Newton gave up his hypothesis that the moon was a falling body, as long as he was unable to show that the amount of its deflection from a tangent (or fall) in a given time, was exactly what it should be, if the moon was controlled by the same force as falling bodies on the earth."*

[HINTS The Method of Residues]

(g) *Napoleon's Russian expedition was the cause of his downfall.*

[HINTS: *Post hoc ergo propter hoc.* Also see p. 314]

EXERCISE XIV

1. The following are the results of a series of experiments conducted by Dr. Wells in order to discover the cause of dew. What methods are employed?

(*a*) In general, it has been found that those substances are most strongly dewed which conduct heat worst, while those which conduct heat will resist dew most effectively.

(*b*) All instances in which dew is deposited have this feature in common; they either radiate heat rapidly or conduct it slowly. All instances in which no dew or very little dew is deposited have in common the opposite feature.

(*c*) It is possible by cooling the surface of any body to find some temperature lower than that of the surrounding air at which the dew begins to appear.

2. In the following cases, what are the conclusions and by what methods?

(*a*) A bell struck in vacuo gives no sound; while light traverses an airless medium.

(*b*) As a body passes from a lower to a higher temperature, it invariably undergoes a change of volume, generally the direction of expansion, but sometimes (as in the melting of ice) in that of contraction.

(*c*) When the cork of a bottle of soda-water slightly warmer than the surrounding air is expelled by the elastic action of the "carbonic acid" gas, the bottle becomes cooler than the surrounding air

3. Describe the logical character of the following arguments, and discuss their validity:—

(*a*) "That the Tempest belongs to the latest period of Shakespeare's literary activity is shown, *inter alia*, by the absence of rhyme, the large number of "run on" (unstopped) lines, the high proportion of weak and light endings, and the comparative rarity of puns in the low scenes"

(*b*) "The increase of agrarian crime, say the judges, was coincident with activity of the Land League, and the decrease of agrarian crime with the inactivity of the Land League."

(*c*) "A person is in sound health mentally and physically. The breaking of a minute blood-vessel in the brain causes a clot of blood there, which is followed immediately by unconsciousness and soon afterwards by death Hence the existence of mind depends on the healthy functioning of the brain."

4 Analyse the nature of the argument, and criticise the reasoning in the following:—

(*a*) Stories are frequently heard of a wonderful feat performed by Indian jugglers It is claimed that a rope thrown into the air retains its upright position A boy then climbs the rope and disappears. Many years ago a learned society in Madras gave wide publicity to an offer of Rs 500 to any one who could do the trick or prove that it had never seen one who could do the trick or prove that it had ever been done.

As no one claimed the reward, the society took it as proved that the stories were false.

(*b*) In a mining town in the Western States of America the boast was made that, except through accident or foul play, there had been no deaths in the past three years. It was claimed, therefore, that the town was exceptionally healthy.

(*c*) Persons coming on to a district in which malarial fever is prevalent usually remain free from such fever, if they protect themselves from mosquiot-bite, while a large percentage of those who carelessly expose themselves to mosquito-bite contract this fever. Moreover in marshy districts in which this fever has been prevalent, it disappears in proportion as the water is drained away; and the mosquito can only breed in water

(*d*) Several of my friends who passed the School-Leaving Certificate Examination in the second division have passed the Intermediate Examination in the second division. Therefore, I hope to pass the Intermediate Examination in the first division, having passed the School-Leaving Certificate Examination in the first division.

5. Test the validity of the following arguments, and indicate the nature of fallacy, if there is any:—

(*i*) We daily see with our own eyes that the sun rises in the morning, travels across the sky, and sets in the evening while our own planet remains stationary. Therefore, it is certainly wrong to say that the Earth moves round the Sun.

(*ii*) The heavy failure in the Intermediate Examination of the present year must be due to an increase in the number of Intermediate Colleges for during the previous years, when the new colleges had not come into existence, the results were not so bad

(*iii*) Ramchandra's friend must have died of influenza for that is the most common disease of the present season.

(*iv*) Joseph's son must be very intelligent, for he behaves exactly like one of my own students, who I know is an exceptionally bright boy.

(*v*) It has been found that the number of criminals who can read and write is much larger than the number of those who cannot Can it therefore, be maintained that education tends to diminish crime?

6. Analyse the following arguments, discussing their validity and indicating the method used:—

(*a*) Do games influence the character of young men? The Principal of a College insisted that every student must spend some time every day in the play ground. In the course of a few months a distinct change in the tone of the College was observed. The students were more manly, straightforward, and honest than before. The

Principal left the college and was succeeded by another who had more faith in reading books Not long after any one could see that though the students of the College did better in the examination, they had distinctly deteriorated in character

(b) On a board where a number of ants was wandering about, I put some small pieces of wood, and on these pieces of wood I put some honey I then put some ants on the honey and imprisoned them. While these ants were imprisoned very few ants came to the honey. But after the imprisoned ants were released, within three-quarters of an hour 54 ants came. The conclusion seems to be that ants can communicate with one another.

(c) In India, it has been noticed that as soon as the hot weather begins, epidemics often take place and we have either Cholera or Small-pox or Fever. It is clear therefore that the hot weather brings disease, but it is also true that plague is worst during the cold weather. Are we to say, therefore that cold also causes an epidemic?

7. Analyse the following arguments and discuss their validity, pointing out fallacies, if any:—

(a) It is said that a large number of babies die in India either at birth or within the first two years after birth and a large number of mothers also die in giving birth to children These deaths are said to be due to ignorance of rules of sanitation and neglect of modern medical science But this cannot be true as there are millions of babies and mothers who are alive and so after all modern medicine and surgery are not necessary to prevent the death of babies and mothers.

(b) The price of food-stuff has gone up enormously during the last twenty years. It is within the memory of some people that 'ghee' at one time was sold 5 seers to the rupee, and only a few years back, wheat could be had at the rate of 40 seers to the rupee. During this time the area of land under irrigation has greatly increased and Railways have been built The cause of India's poverty must therefore be increased agriculture and the Railway system of the country.

(c) The people living in cold countries generally possess a good physique, for Englishmen and Afghans who come to India are generally tall and well-built On the other hand, people living in hot climate are weak and short. But there are many hill tribes who are short of stature and yet strong Has climate anything to do with the growth of the body?

(d) People who do not go to school generally have good eye-sight Among students those reading in colleges suffer from short-sightedness more than school-boys, and even college students have better sight than

their Professors Education is the cause of weak eye sight.

8. Analyse the following arguments, and discuss their validity pointing out fallacies, if any:—

(*a*) The establishing of new Universities in recent years has greatly advanced the cause of higher education in India. The percentage of passes in some of them is very high—about 90 or 95. In one of them, not only did all the students in a post-graduate class pass the examination, but every one of them did also obtain a first class. The older Universities cannot keep pace with the new Universities Everywhere, old age means exhaustion and inefficiency.

(*b*) The number of qualified medical men has considerably risen during the last ten or fifteen years In large towns, one finds dispensaries and hospitals on all sides But has all this resulted in any improvement in the health of the people? The number of in-door and out-door patients has been steadily rising Medical men and medical halls have tended to increase disease rather than decrease it.

(*c*) Who pays for the advertisement—the seller or the buyer? Neither, the advertisements pay for themselves The more you advertise your goods, the more you sell Increase in production means lowering the cost of production, and the saving thus effected will suffice to pay for the advertisement.

9. Criticise the following arguments:—

(*a*) Riches are a power like that of electricity. To get work out of electricity, it must be allowed to flow from a place of high to a place of low potential Similarly, the force of the guinea you have in your pocket depends wholly on the default of a guinea in your neighbour's pocket.

(*b*) A certain tourist who travelled up and down this country for a few months observed many under-fed, diseased, and uncared-for cows in the streets and in 'goushalas' and 'pinjrapoles' She subsequently proclaimed to the world that she had seen with her own eyes how unkind the people of India were to the cow whom they professed to adore.

(*c*) There are general indications that the lot of the Indian agriculturist is now better than it was in the past. The multiplication of third-class passengers on the railways during the last decade, the increase of bullock carts and other wheeled traffic in most India districts, so also the increased absorption of rupees, which has taken place of late years, all go to show that more money is now available after the bare necessaries of life have been procured than there was previously.

10. Analyse fully the following arguments and discuss their validity, pointing out and explaining fallacies, if any:—

(*a*) In a certain college, students were given intelligence tests The results showed that Science classes were on the whole more intelligent than Arts classes It is clear, therefore, that Science tends to develop the intelligence of a student

(*b*) In Russia, the Revolution was brought about by the Bolshevists, in China also, the Bolshevists had something to do with the revolution; in India Bolshevist agents are said to be encouraging the revolutionary party. The natural conclusion seems to be that the French Revolution and the Revolution in Turkey must have been engineered by Bolshevists

11. Criticise the following:—

(*i*) There is a disease called cretinism which produces a stunted condition of body and mind. In cases where the symptoms of the disease are present, there is found to be an insufficient amount of secretion from the thyroid gland, and the less the secretion, the more pronounced the symptoms. When treatment with a preparation of thyroid is tried, the symptoms gradually disappear If the treatment is stopped, the symptoms reappear.

(*ii*) To prove continuity and the progressive development of the intellectual faculties from animals to man is not the same as proving that these qualities have been developed by natural selection Because man's physical structure has developed from an animal form by natural selection, it does not necessarily follow that his mental nature, though developed with it, has been developed by the same cause only.

(*iii*) Water boils at a higher temperature on low elevations than on the mountains, the circumstance which explains the difference here is that the pressure of the surrounding atmosphere is greater in the former instance, less in the latter. The surrounding atmosphere by itself, and change in its pressure, do not make water boil; not until heat is introduced does boiling occur.

(*iv*) Sir Charles Lyell, by observing the fact that the river Ganges yearly conveys to the ocean as much earth as would form sixty of the great pyramids of Egypt, was enabled to infer that the ordinary slow causes now in operation upon the earth would account for the immense geological changes that have occured, without having recourse to the less reasonable theory of sudden catstrophes

(*v*) Great Britain has had continual trouble in Egypt since the construction of the Suez Canal; this canal is, therefore, the source of the trouble.

12. Examine the following, bringing out the character of the argument, stating it in logical form as far as possible, and naming the argument (whether fallacious or not) by its logical name:—

(*i*) The great argument for universal increase of armaments is that any nation which makes itself strong makes itself respected and feared.

(*ii*) It is difficult to understand why a statesman should lay himself open to the charge of little-mindedness by harping upon his consistency, which it is well known is the failing of little minds.

(*iii*) I am accused of inciting to sedition by the address which I delivered to the meeting But there is not one man present at the meeting who if my remarks were addressed to him privately, would have been moved to disloyalty.

13. Explain the logical character of the following arguments; indicate the methods which are used in them; and examine their validity:—

(*i*) There are no great nations of antiquity but have fallen by the hand of time; and England must join them to complete the analogy of the ages. Like them, she has grown from a birth-time of weakness and tutelage to a day of manhood and supremacy; but she has to face her setting. Everything that grows must also decay.

(*ii*) Worms do not possess any sense of hearing. They took not the least notice of the shrill notes of a metal whistle, which was repeatedly sounded near them; nor did they of the deepest and loudest notes of a bassoon. They were indifferent to shouts if care were taken that the breath did not strike them. When placed on a table close to the keys of a piano, which was played as loudly as possible, they remained perfectly calm.

(*iii*) Goldscheider proved that muscular sensations play no considerable part in our consciousness of the movements of our limbs, by having his arm suspended in a frame and moved by an attendant Under these circumstances, where no work developed on the muscles, he found he could distinguish as small an angular movement of the arm as when he moved and supported himself.

(*iv*) He also proved that the chief source of movement-consciousness is pressure-sensations from the inner surface of the joints, by having his arm held so that the joint surfaces are pressed more closely together, and finding that a smaller movement was now perceptible.

(*v*) A unique phenomenon of colouration in the sky occurred in 1883 In the same year a tremendous volcanic explosion occurred in the Straits of Sunda, and that also was of unique intensity. The coincidence of the two led to the belief that the one was the cause of the other.

14. Test the following arguments, naming the fallacies, if any, or stating the experimental method employed, as the case may be:—

(*a*) "It has been shown by observation that over-driven cattle, if killed before recovery from their fatigue, become rigid and putrefy in a surprisingly short time A similar fact has been observed in the case of animals hunted to death, cocks killed during or shortly after a fight, and soldiers slain in battle The contrary has been remarked when the muscular exercise has not been great or excessive Hence we may infer that cadaveric rigidity depends upon a more or less unirritable condition of the muscles immediately before death" (Hyslop).

[HINTS: The Joint Method]

(*b*) The locomotive of a fast express train struck a crowded street car and killed half the passengers It was ascertained that those who survived worse a certain medal while those who lost their lives did not

[HINTS: *Post hoc, ergo propter hoc* (see p 316)]

(*c*) Suppose there is a peculiar odour coming from the direction of the refrigerator On investigation we find that the butter, meat, fruit, and indeed each of the other articles in the board has an odour which cannot be identified with that we first perceived. The real cause, then is outside the refrigerator Further search reveals the presence of some decayed flowers lying in a nearby corner.

[HINTS: The Method of Residues.]

(*d*) The people you see in this portion of the city are not only poor but shiftless; they are foreigners; all foreigners are poor and shiftless.

[HINTS · Induction by Simple Enumeration The fallacy of Illicit Generalisation]

(*e*) The more a body is heated, the more it expands

[HINTS · The Method of Concomitant Variations]

(*f*) Cocoanut trees best flourish in places nor far removed from the sea.

[HINTS · The Method of Agreement]

15 Criticise this argument; "Opium cannot be injurious, for I have just read in the papers of the death of a confirmed opium-eater at the ripe age of 95 years"

[HINTS Fallacy of neglecting negative conditions]

16 Criticise the following statement "You brought a curse upon my house, for no sooner had you left it than the lightning struck my roof"

[HINTS *Post hoc ergo propter hoc*]

17 Is it logical to say, "John Smith must be a good student, for his brother won a mathematics prize?"

[HINTS *Ignoratio Elenchi.*]

18 Criticise the statement "I said in my haste that

all men are liars."

[HINTS Induction per simple Enumeration.]

19. Construct a Hypothesis to explain some fact in your own experience, and explain how it may be verified or overthrown.

20 Construct an argument to show the harm or the benefit of some habit, and analyse your reasoning, showing the methods which you have employed.

21 Criticise the following arguments.—

(*a*) "Father, why, does the tiger have sharp claws?"

"My child, it is because it belongs to the cat family."

(*b*) If the Holy Man shall curse you, you will surely meet calamity before the month has passed.

(*c*) It is nobody's concern if I drink, and beat my wife; for a man may do what he will with his own.

22 How would you proceed, by experiment or observation to prove (or disprove) the belief that the stars have an influence on a man's life? (*N B*—The candidate may prove or disprove as he pleases.)

23 Several large towns in the north of England are engaged in textile (cotton and woollen goods, for example) manufacture and in these towns infant mortality is very high A, B, C and D, are textile manufacturing towns and must therefore have high infantile mortality.

What kind of argument is this, and what inductive fallacy would be committed if the universal conclusion "All textile manufacturing towns have high infant mortality" were drawn from the facts given above?

24 Analyse logically the following passage· "In all unhealthy countries the greatest risk of fever is run by sleeping on shore Is this owing to the state of the body during sleep, or to a greater abundance of miasma at such times? It appears certain that those who stay on board a vessel, though anchored at only a short distance from the coast, generally suffer less than those actually on shore" Darwin—Voyage of a Naturalist.

25 Discuss inductively the proposition that it would be for the general good to extend the right of voting for members of the Legislative Assembly to women

26 Discuss the following argument "Just as the flint and bone weapons of rude races resemble each other much more than they resemble the metal weapons, and the artillery of advanced peoples so the mental products, the fairy tales and myths of rude races have everywhere a strong family resemblance"

27 Construct an argument to prove: "That the sole justification of punishment is to educate the offender." Reply to your argument, and analyse both argument and

counter-argument, pointing out how far each is inductive and how far each is deductive.

28 From observation, many instances of male birds of a certain species having bright and female birds having dull feathers have been gathered. Discuss the methods by which one would attempt to establish that all male birds of these species have bright and all female birds dull feathers.

29. A certain school had 150 pupils on its roll One morning the attendance suddenly fell to 50. The average attendance had been 130, the remaining 20 being accounted for by slight ailments, social engagements, and indifference. There was no epidemic or mela in the neighbourhood to account for the sudden drop. There had been, however, a number of political meetings in the town recently. So the Head Master concluded that fact accounted for the unusual number of absentees.

By which of Mill's Methods was this conclusion reached?

From the example given show the characteristics and the defects of this method

30 *Test the following*:

(*a*) When a body passes from a lower to a higher temperature, it invariably undergoes a change of volume in the direction of expansion. Therefore, heat is the cause of expansion.

(*b*) Prof. Rammurti once weighed an elephant on his chest. A person who witnessed the performance concluded that Prof Rammurti was a great magician.

(*c*) Rat-fall, which is seen to precede the outbreak of plague in man, is the cause of the latter.

(*d*) Pure water is the cure of many diseases, for, it is found in all mixtures curing such diseases.

(*e*) A child is like soft clay You can mould it in any way you like.

(*f*) Even the teacher could not solve the problem. How can a student expect to succeed?

(*g*) Glass is transparent. The reason is that it can be seen through.

(*h*) He must have died of cholera as cholera is now raging in the town.

(*i*) God must exist, because Scriptures say so.

(*j*) Since opium is soporific it produces sleep.

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